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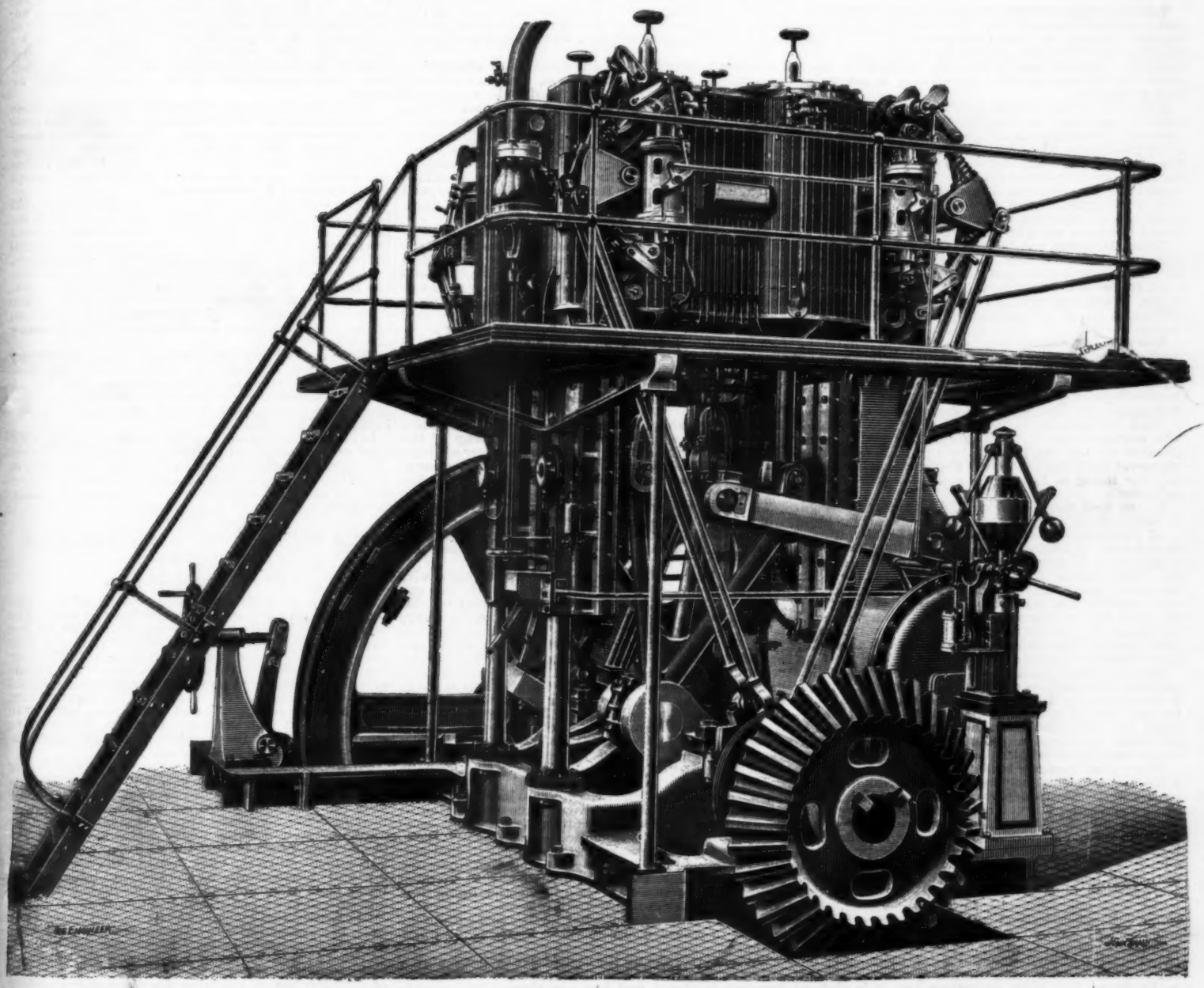
IMPROVED QUADRUPLE EXPANSION ENGINES.

WE give an illustration of a set of quadruple engines constructed for the Wesselton Diamond Mining Company, Kimberley, by Messrs. Fleming & Ferguson, engineers and shipbuilders, Paisley. The engines are a set of the makers' patent quadruple surface condensing engines, capable of indicating 500 horse power. The diameters of cylinders are 12 in., 18 in., 24 in., and 34 in., all having a stroke of 3 ft.; the working speed of the engines is 80 revolutions per minute, and the boiler pressure 200 lb. per square inch. The boilers are of the tubular under-fired class, and made by Messrs. Fleming & Ferguson. The crank shaft is of the built type, all forged from steel ingots, the cranks having solid counterweights as a balance for the cranks and connecting rod ends. The first and third cylinders are connected to one crank pin by a triangular connecting rod, and the second and fourth cylinders to the other crank pin by same type of connecting rod. All the valves are of the Corliss type, and are double ported both for exhaust and for steam. The steam valves are fitted with most improved trip motions. The valves of the first and third cylinders being directly controlled by a governor, this arrangement gives a very complete and perfect control of engine speed, as the governor when acting on the cut-off of the third cylinder brings at same time compression into play in the second cylinder. When desired the valves of first and fourth cylinders may be controlled by a governor. The trip motion on the second and fourth cylinders is adjustable by hand gear. All steam and exhaust valves for any port are capable of independent adjustment. Separate eccentrics are fitted for steam and exhaust valves. The cranks are at an angle of 90 deg., and the cylinders connected to each crank are pitched at a distance on each side of the crank shaft such as makes their angle of action to one another 45 deg. This causes the turning power on the crank shaft to be very equable, there being eight points on the crank circle at which the cylinders act, in place of four as in the ordinary quadruple, and six in the ordinary triple expansion three-crank engine; the triple expansion engine being better than the ordinary quadruple in this respect, has hitherto had the advantage in turning power; but in Messrs. Fleming & Ferguson's arrangement their engine has the advantage over the three-crank triple by two points.

The power is taken from the engines on both ends of the crank shaft. At the fly-wheel end of the crank shaft a steel pinion 3 ft. diameter, having teeth 4½ in. pitch and 20 in. broad—not shown in the engraving—gears into a spur wheel 9 ft. diameter, fixed to the main driving shaft. This shaft drives a number of compound milling and washing pans, elevator, traveling bands, etc. From the other end of crank shaft power is taken by means of miter wheels to transmit 200 horse power for driving haulage windlasses, working pumps, and crushing shaft rollers. All the above wheels are milled to give smooth running.

The engines were tried under steam at Messrs. Fleming & Ferguson's before being shipped, and although they were only sitting on the shop floor without holding-down bolts of any kind, they were driven at their full working speed, and while thus running had no perceptible movement or vibration. We are indebted to *The Engineer*, London, for our illustration and the foregoing particulars.



IMPROVED QUADRUPLE EXPANSION ENGINES.

BLAKE NEW HIGH DUTY PUMPING ENGINE.

WE present on page 14473 a cut showing the high duty cross compound automatic cut-off pumping engine made by the Geo. F. Blake Manufacturing Co., of New York and Boston, which shows some novel ideas in construction which we believe to be of interest.

The engine is of the direct-acting, fly-wheel, cross compound type, having one high pressure and one low pressure steam cylinder with two double-acting inside plunger pumps. Both high and low pressure steam cylinders are provided with a Corliss automatic valve gear. The axis of each steam cylinder coincides with

that of its corresponding pump cylinder. The fly wheel is placed between the cylinders and is attached to the piston rods through connecting rods, beams and links. The air and feed pumps are driven from the beam shaft of the low pressure cylinder. The pump cylinders are provided with a great number of small valves, giving a very large area for the passage of water to and from the cylinders.

The dimensions of the engine are as follows:

Diameter of the high pressure cylinder	21	inches.
Diameter of the low pressure cylinder	42	inches.
Diameter of two pump plungers	13½	inches.
Diameter of all piston rods	4	inches.
Stroke of all pistons and plungers	40	inches.
Diameter of one single acting air pump	26	inches.
Stroke of same	12	inches.
Diameter of single acting plunger feed pump	4½	inches.
Stroke of same	6	inches.
Diameter of pump plunger for returning reheater drain to boiler	2	inches.
Stroke of same	6	inches.

The grate of the boiler was measured and found to be 7 feet long and 7 feet wide, less a longitudinal separating wall, 7 feet long and 13½ inches wide. The steam at the boiler was assumed to be dry and saturated.

THE COLLAPSE OF FOUNTAIN LININGS.

By THOMAS WARWICK.

THERE are two varieties of collapse with which druggists are unfortunately but too familiar; collapsed fountain linings and collapsed pocketbooks. In fact the two very often go together, for in this nineteenth century the pocketbook is the pressure gauge or indicator that informs us when everything is not going just as it should.

Fully nine-tenths of the troubles experienced with portable fountains are due to this collapsing, and consequently the subject is of considerable importance to every pharmacist who dispenses soda water. Moreover, the causes of the collapsing are so imperfectly understood by the majority of dispensers that they come to regard it as a necessary evil, one from which no amount of care will guard them; when in reality, if proper precautions were observed, the collapse of fountain linings would become a thing of the past.

Before, however, considering the prevention of this collapsing, we must first understand what we mean by the term, and afterward what the causes are which tend to produce this "buckling in" of the soft metal lining. Then, and then only, can we hope to discover efficacious means for preventing these annoying accidents.

Every properly constructed portable fountain on the market consists of a strong metal shell inclosing an inner vessel made of sheet block tin. Now the tin vessel is, of necessity, quite weak, and could hardly stand any pressure at all were it not for the stout metal shell that incloses it. But while this shell suffices to preserve it from all danger due to internal pressure, it cannot offer any assistance if there happen to be an external pressure on the tin lining. In this case, or at least whenever the outer pressure is stronger than the inner one, the lining is forced in—or, in technical terms, it collapses.

Let us first consider the disadvantages of this collapsing. Evidently one of the results of the buckling in of the lining is that the capacity of the fountain is diminished. A fountain which before the collapse had a capacity of 15 gallons may now only be able to hold 14. This, however, is not a matter of vital importance; the great danger is that, in collapsing, the lining has become weakened or injured. This is almost inevitably the case, and as, when the fountain is charged again, the lining will usually be forced out to its normal position, it follows that repeated collapsing will sooner or later cause it to spring a leak.

With stationary fountains the collapse of the lining produces other serious disadvantages; for if the lining is forced in too far, it will prevent the agitator from turning; and if the operator resorts to force to overcome the unwonted resistance which he meets with, the result may be a serious injury to the lining or agitator—sometimes to both.

In any case, however trifling the injury to the lining, if the fountain leaks, the dispenser must resign himself to the very unsatisfactory remedy of sending it to the manufacturer for repairs, an entire new lining being usually required. The expense is considerable, especially if the freight charges be added; and the druggist is deprived of the use of his fountain for probably a couple of weeks, which may mean a serious loss to him during the height of the busy season.

We are now prepared to consider the different causes which may produce a collapsing of the lining. It is claimed by some soda water manufacturers that the weight of the water in the fountain may sometimes be sufficient to cause collapsing, especially if the fountain be violently agitated—for the water, by pushing out the fountain at both ends, necessarily causes the sides to be drawn in. With generators, too, it is claimed that the weight of the materials (especially in vertical generators) may cause collapsing by thus drawing down the lining. But while such a case might possibly arise, I very much doubt if it really ever occurs in practice.

Leaving this case, therefore, out of consideration as immaterial, we find that all cases of collapsing of linings are due to the fact that a partial vacuum is formed in the fountain, and the weight of the atmosphere then forces in the soft metal lining. There is but one possible exception to this rule. It is in the rare case when some external pressure other than that of the atmosphere can be brought to bear against the outer surface of the tin lining. This sometimes happens when there is a small pinhole in the lining. If the fountain then be left charged for any length of time, a certain amount of gas will be forced through this pinhole, and find its way behind the lining, where it will be confined between the lining and the outer shell. If now the fountain be emptied, there will be nothing to counterbalance the pressure exerted by this gas behind the lining; and as it has not time enough to escape through the pinhole, the natural consequence will be that the lining will be forced in by the pressure of the imprisoned gas.

I have known such cases to occur, and unfortunately there is no remedy for them, except to put in a lining without pinholes. But I must say that comparatively few cases of collapsed linings are due to this cause.

Turning now to those much more numerous cases where the trouble is due to the formation of a vacuum in the fountain, let us see in what ways such a vacuum may be formed. A fountain always contains either water, carbonic acid gas, or air—usually all three together. Now, water being incompressible, it follows that if a vacuum be formed it must be either by the absorption of air or gas by the water or by the compression of the air or gas.

The first cause is perhaps the most frequent and the least understood. A fountain that has been once charged with soda water will, even when emptied and left standing with the cock open, retain a considerable quantity of carbonic acid gas. Now this gas is readily soluble in water; consequently if the druggist, when about to make a charge, pours his cold water into the fountain, and then closes the stop cock, the metal lining will collapse at the end of a few minutes; for, the cold water absorbing its own volume of carbonic acid gas, a vacuum is formed in the interior of the fountain, and, as we have seen, the formation of a vacuum will in all cases produce a collapse of the lining.

Agitation, too, as it favors the absorption of gas by the water, may produce the same results; hence, fountains should never be agitated until they have an internal pressure of ten or fifteen pounds. It is a common practice of dispensers to set their rockers going before admitting gas to the fountain; and as this favors the absorption of the gas by the water, it will also favor the production of a vacuum and consequent collapse.

Having thus considered the question of absorption, we come to that of compression. In what different ways can the air or gas in the fountain be compressed so as to form a partial vacuum? There are several, the most common one, perhaps, being by a reduction in temperature. If an empty fountain be tightly closed during the daytime, a certain amount of air will be imprisoned; and as during the night the temperature will fall, it follows that the air will be compressed into a smaller volume by this reduction in temperature, and a partial vacuum will be formed. Result, an unexplained collapse of the fountain lining.

Another common cause of collapse caused by compression occurs in the case mentioned above when the fountain is agitated before the pressure has reached ten or fifteen pounds. In such a case, when the fountain is rocked, the water is dashed violently from one end of the vessel to the other, compressing the air or gas in front of it, and so creating the empty space that nature abhors. This is especially liable to occur if the fountains are agitated on a frame instead of on a rocker.

There is one more cause of collapse to be considered: When a fountain is discharged in such a way that air cannot find its way in as fast as the water is discharged the old trouble will manifest itself. This frequently happens in washing out portable fountains, for, when emptying the water through the only bung of the fountain, the egress of the liquid prevents any air from entering. Consequently, as soon as a certain amount of water has escaped, a vacuum is formed and the lining collapses.

This completes the record of the various causes which may produce a collapse of the lining; and a careful consideration of the points brought up will show us what precautions are necessary in order to avoid this trouble.

It may be asked at this stage of the inquiry, why manufacturers do not make a lining that will not collapse. Perhaps at some future day they may be able to do so, but up to date all efforts in this direction have failed. To increase the thickness of the linings is quite expensive, and, while it reduces the chance of collapsing, the injury to the lining from each collapse is correspondingly increased, so that little if anything is gained. In like manner the various attempts made to strengthen the lining by ribs or by stays and braces have been found unsatisfactory. To use a wash or thin coating of metal instead of a sheet lining, while it does away with collapse, exposes the beverage to noxious contamination if a portion of the coating should wear off or become injured, which contingency is continually occurring.

To make an air-tight external case has also serious disadvantages. Various devices have been patented at one time or another for preventing the collapse of linings by means of automatic devices which serve to keep the internal pressure always equal to that outside the vessel; but it has been found that these devices require more care to keep in good working order than would be necessary to prevent the lining from collapsing under ordinary circumstances.

We shall now consider what are the precautions necessary to secure complete immunity from collapsed linings.

Let us first take up the case of portable fountains. We have seen that the trouble can only arise when the fountain is closed and has less than fifteen pounds pressure internally. Consequently, the first rule to be borne in mind is: When the fountain is not under pressure the cock should be left wide open. Then, no matter what happens, the internal pressure can never become less than that outside, no vacuum can be formed, and no collapse can occur. But there is so much danger of the cock being closed through inadvertence that the only really safe rule is to take the cocks completely out of the fountains whenever the latter are not under pressure.

Especially is this necessary when shipping fountains to a distance. Under no circumstances should the cock be left in the fountain, for it will almost certainly be closed in transit, and the lining will run great risk of reaching its destination in an absolutely worthless condition.

As, however, impurities of all kinds might fall in through the open bunghole, and it might be difficult to properly clean the fountain afterward, a good plan is to force a square plug of wood into the bung. This will leave a free passage for the air, but will prevent most other substances from finding an entrance. Moreover, the plug will afford a convenient hold for those who handle the fountain in transportation.

The second great principle to bear in mind is: Never to agitate the fountain until the pressure on the gauge shows about fifteen pounds to the square inch. Moreover, the druggist should be careful to close the cock of the fountain only at the very last moment, just when he is ready to begin generating the gas; for otherwise, as we have seen, the absorptive powers of the cold water may be sufficient to cause collapse. This is a point of such importance, and is so frequently overlooked by the large majority of druggists, that I desire to lay special stress upon it.

When it comes to the question of washing out portable fountains, while the danger is greatest here, there are not many cases of collapse from this source, as the majority of druggists do not consider it necessary to wash out their fountains, believing that the soda water that passes through keeps them perfectly clean. In fact, it is rare to find a man who makes it a point to wash them even once a year.

Now, while it is true that the soda water does to a certain extent keep the fountain clean, it is also undeniable that some foreign matter adheres to the lining, and will, in the course of time, give the soda water a musty odor and even a perceptible taste. Hence it is well to occasionally wash out the fountains: and if done in the proper manner, no danger of collapsed linings need be apprehended.

The special machines for washing fountains are too expensive for the druggist, but all that he really needs is a stiff tube about six inches longer than the fountain. With the aid of this tube it is easy to discharge the water from the fountain without creating a vacuum, for if the tube be inserted through the bung of the fountain it will allow the air to enter as fast as the water is poured out, and will thus prevent all danger of collapsing. It is possible, by turning the fountain slowly and with great care, to discharge the water without causing a collapse, but the danger is so great that every druggist should use a tube as above directed.

The linings of generators are much thicker than those of portable fountains, but they will collapse in the same way and from the same causes. The rules for generators, however, differ slightly from those for fountains, although the principal rule is the same, namely: That the generator must not be left tightly closed, except when the vessel is under pressure.

When shipping a generator, too, all the caps should be taken off, so that the air may have free access to the interior of the gas washers, the vitriol chamber, and the generator body. Each of these has its own special lining, which can collapse independently of the others.

When discharging a generator, as soon as the pressure has fallen to say about five pounds to the square inch, one of the upper caps should be opened to allow for the entrance of atmospheric air and prevent the formation of the dreaded vacuum, which is always the precursor of a collapse.

There are but few druggists who employ stationary fountains, but those that do will find that the same rules apply for these as for the generators, with the additional one that the agitator of the stationary fountain should not be set in motion until the pressure gauge indicates at least ten pounds.

In conclusion I would say that, while the subject is a most complicated and difficult one, yet if the general principles are once understood and are well borne in mind, the druggist can with a little care entirely prevent the annoying collapsing of his generator or fountain linings.—*Bulletin of Pharmacy.*

THE PAINTING OF WOOD AND IRON STRUCTURES.*

By EDWARD H. BROWN.

A PAINT, properly speaking, consists of two portions—the pigment and the vehicle or binder. The pigment is a solid substance which is more or less finely ground, so as to be capable (when mixed with the vehicle) of being spread out in a thin layer or coating over the surface to be painted. The vehicle or binder is the liquid in which the pigment is mixed or ground, which serves to spread the pigment over the surface to be painted, and which also holds it to that surface. For ordinary painting, intended to stand the action of the weather, by far the most generally useful vehicle is linseed oil.

Linseed oil possesses the peculiar property of drying by uniting with the oxygen of the air to form a tough, leather-like compound called linoxin. In doing this it loses but little, if any, weight, whatever weight may have been lost by evaporation being supplied by the additional weight of the added oxygen. This drying or oxidizing process seems to take about thirty days to complete, when the oil is spread out in a very thin layer. It has generally been supposed that linseed oil formed a waterproof and water-repelling coating on any surface to which it is applied; but Dr. Charles B. Dudley, the chief chemist of the Pennsylvania Railroad, in a recent series of experiments made by him, seems to have proved that this is a misapprehension, and that in reality it is an absorbent of moisture, and will transmit air through it. Moreover, in the process of drying it has an oxidizing tendency on the surface upon which it is placed.

While these characteristics of linseed oil are rather an advantage than otherwise in the case of paints to be applied to wooden surfaces, they make it a dangerous vehicle to use in paint intended to be applied to iron construction, where absolute impenetrability to gases and moisture is essential in order to prevent the metal from being eaten away by rust. Hence, it would seem that for a perfect paint for use on ironwork we must look for a vehicle which, when dry, is impervious to moisture and gases, and, moreover, one which will be chemically inert and in no way aid the process of rusting. Another very important property of linseed oil which makes it valuable for paint making is the fact that it is capable of uniting with various metallic bases (usually in the form of carbonates or oxides) to form a linseed oil soap.

White lead, or the hydrate-carbonate of lead, the pigment usually used in house painting, and generally esteemed to be of most value, unites with the oil to

* Abstract from a paper read before the Engineers' Club of Philadelphia.

form a lead soap, on exposure to the oxygen of the air, thus forming an elastic skin of paint over the surface to which it has been applied. In time, by the gradual action of water, alternating with the heat of the sun, and aided more or less by the sulphur and other gases in the air, particularly in and about large cities, this soap gradually decomposes, and the paint begins to chalk or flour off. Zinc white, or the oxide of zinc, also unites with linseed oil to form a zinc soap, which is harder and more brittle than the lead soap, and has a tendency to contract or pull together when drying, and also to peel off in time. It has not the same tendency to chalk and flour that the white lead soap has. Zinc white has, therefore, valuable pigment properties, but these seem to be most fully developed when this pigment is used in conjunction with white lead, and then to the best advantage when the mixture is used as a final coat over an elastic undercoating of white lead.

On account of the peculiar chemical activity of a white lead and linseed oil paint, which causes its final decay, many experiments have been made looking to the substitution of some chemically inert substance for the more active carbonate of lead; but, so far, no other white base has been discovered which possesses at the same time the other properties which render white lead valuable, namely, covering and spreading capacity. It seems, therefore, probable that if a better paint than lead and oil is desired, experiments will have to be directed rather toward securing an inert vehicle than toward an inert base.

Of the inert pigments, lampblack is probably the most valuable. Being almost pure carbon, it is practicably unchangeable except by fire. It has a peculiar property of absorbing great quantities of linseed oil, and hence of spreading over a large surface. French ocher, an earth pigment, containing more or less of the hydrated oxide of iron, possesses the property of absorbing a large quantity of oil, and hence has considerable spreading capacity, and also holds very firmly to any wooden surface to which it may be applied. As this makes a reasonably cheap paint, it is very good to use on rough work where the yellow or yellow-brown color is not objectionable. It has the merit of great durability, and repels water well. It should be ground in raw linseed oil, and if a thinner is required, care should be taken that boiled oil is not used. The raw oil possesses greater penetrative properties and carries the ocher farther into the pores of the wood. Ocher has been recommended by some as a primer for use under subsequent coats of white lead. While it has undoubtedly the property of holding fast to the wood itself, it does not hold as well to the white lead coats, which sometimes separate from it in flakes. This could probably be avoided by the addition of a certain proportion of white lead to the ocher for the priming coat.

The various mineral and metallic paints are almost all natural or artificial iron oxides. While these are cheap and useful for painting rough wooden structures, they are sometimes really quite dangerous for application to ironwork, because, instead of preventing oxidation, they are apt to further it. Mineral paints are usually iron oxides, similar in their nature to rust. Rust is a hydrated iron oxide, and seems to possess the peculiar faculty of spreading from a center, in some way acting on the adjacent iron to form additional rust; moreover, the artificial metallic paints are frequently made from copperas and from pyrites, and are apt to contain sulphuric acid or sulphur in a state readily oxidizable into sulphuric acid, which is another source of danger to an iron surface. On wood, however, they are permanent in color and exceedingly preservative. Coal tar is much used as a paint for the roughest class of work, both wood and iron, in the latter case especially for cast iron pipes, smokestacks, and work to be buried underground. It has the nature both of resin and an oil.

Muelder, in a series of experiments, found that it continually decreases in weight, losing from two to five per cent. in eighty-seven days. It has also the disadvantage of becoming exceedingly brittle by the action of cold and softening at 115° F. Asphalt permits of somewhat wider range of temperature, but otherwise exhibits the same peculiarities. These substances, while they last, are probably the most valuable of paints, especially under water; but they are unfortunate in their tendency to flow or crawl on the surface to which they are applied, finally leaving the upper portions almost or quite bare. This is the case even underground.

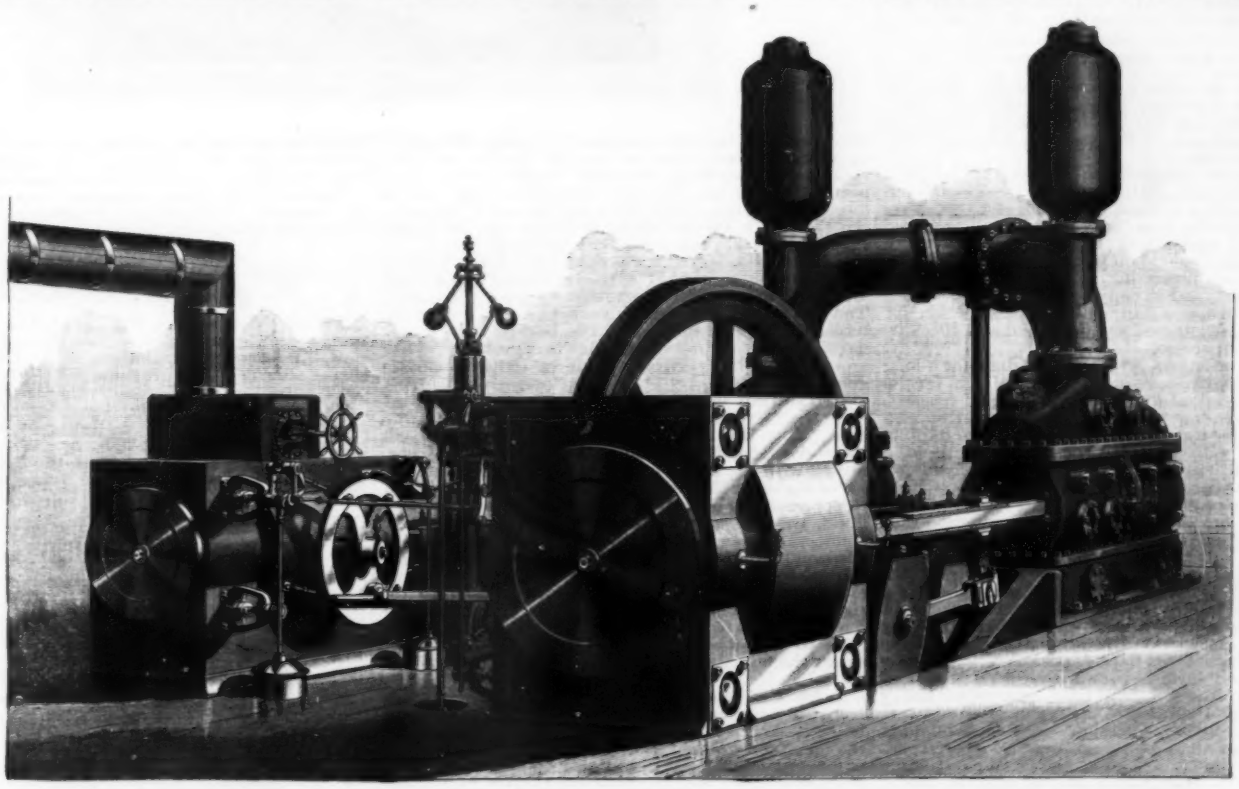
Tin or metal roofs are problems requiring most careful consideration on the part of both engineer and architect. Frequently the tin is allowed to rust before the coat of paint is given, so as to make the paint hold easier, forgetting that the tin is intended to preserve the iron from rust, and when once the tin has gone and the rusting process has commenced, no subsequent coating of paint can prevent it from eating its way through the thin sheet of iron. At the last convention of the Master Painters' Association, of New Jersey, this subject was thoroughly discussed, and the general sense of the meeting seemed to be that the best method of painting a tin roof was to carefully remove all traces of oil or grease from the surface of the tin while it was yet bright, with benzine; then to apply a coat of red lead and linseed oil, or the best quality of metallic paint, and to follow this with one or two coats of graphite paint. The graphite is almost unchangeable by atmospheric action, and is remarkably waterproof as well.

To determine the proper material to use on structural ironwork is perhaps the most important problem that confronts the engineer of construction to-day. In our modern many-storied buildings, this ironwork is buried beneath brick and terra cotta, so that it is impossible to observe its condition. Who can say that the causes of rust and decay are less active here than they are when the same material is exposed? Again, our bridges and the roof trusses in our railway stations are exposed to constant fumes from the locomotives beneath them. The smoke is more or less charged with sulphur gases, which, in a moist condition of the atmosphere, are rapidly changed into the actively destructive sulphuric acid. Already the roof trusses in the Broad Street station, Philadelphia, Pa., have been seriously impaired, and we have had shown to the club at various times a number of examples of rods and plates from overhead bridges which have been nearly eaten through by the action of these gases.

In house painting the most important thing to consider is the permanency and durability of the paint itself. In constructive ironwork, on the contrary, the condition of the surface under the coating of paint becomes highly important. To the superficial observer the painted surface may appear as perfect as the day it was put on, yet underneath it the iron may be slowly, yet none the less surely, rusting away. In fact, it sometimes happens that the paint itself proves an active destructive agency for injuring the iron. This is, as said above, specially true of certain of the metallic paints containing sulphur in a form readily oxidizable to sulphuric acid, or of certain of the oxides, such as Venetian red, which are practically rust themselves and give off oxygen to the iron, absorbing more from the outer air to replace that which has been lost. It is said that a similar process takes place during the oxidation of linseed oil, which changes it to linoxin. Were all the oil to unite with the pigment base to form a soap, then none of its oxygen could be given off to rust the iron; but in the case of white lead, according to Condit, it is only the water lead (the hydrate) which forms a soap with the oil, while the carbon lead (the carbonate) remains practically unchanged, being held, as it were, in suspension in the oxidized vehicle. Hence a large portion of the oil, in drying, is free to give up its oxygen to the iron, absorbing more from the air, and thus become an active rust-producing agent. While this theory may not be correct, it is certain that a priming coat of white lead is not a good preservative of iron, nor does it hold well to it.

Red lead, from the fact that it dries up linseed oil almost entirely by saponification, forming a pure lead soap, and that there is, therefore, none of that oxidation of the oil which takes place in the presence of pigments wholly inert, or which only partially combine with it, has long been regarded as the best possible preservative for clean dry iron. But, in order to be most effective, the iron must be perfectly clean and free from any suspicions of rust, and absolutely dry. Red lead should be perfectly pure, and of the best and most careful preparation. That from any well known corroding house may be depended upon for purity, but not always for quality. It is simply a red oxide of lead. The best type is orange mineral, which is made by roasting white lead. On account of its expense this is not so frequently used as it would deserve. Red lead proper is made directly from the metal, which is first oxidized to the yellow litharge and then to the red oxide. This, however, does not give as good a paint as that made from the scrap, settlings and tailings of the white lead works. As red lead saponifies very quickly with linseed oil, it must be used within a few days after being ground, and, moreover, it is rather difficult to work. Hence there is great temptation to the unscrupulous painter to add some substance, such as whiting, to it in order to make it work freer, as well as to cost less money for material.

Before painting ironwork it is very essential that the iron itself should be absolutely free from rust. Rust has the peculiar property of spreading and extending from a center, if there be the slightest chance to do so. Hence, a small amount of rust on the iron may grow under the surface of the paint, especially if it be true, as Dr. Dudley asserts, that linseed oil is permeable by air and moisture, and in time the paint will be flaked off by the rust underneath, thus gradually exposing the bare surface of the iron to the action of its destroying agents, oxygen in the presence of water. It is necessary to remove all the scale possible from wrought iron by means of stiff wire brushes, and then to remove the rust by a pickle of very dilute acid, which must afterward be thoroughly washed off before the paint is applied. The surface of the iron should be dry, and at least moderately warmed before it is primed. Hence the specifications usually call for the priming with red lead to be done by the iron manufacturer, before its delivery to the job. It has been suggested that rust may be quickly and thoroughly removed from iron by coal oil. This should afterward be washed from the surface with benzine, which should be allowed to evaporate before painting, otherwise the coal oil, being practically non-drying, would inevitably cause the paint to peel from the metal. Red lead, to secure the best results, should be thoroughly incorporated with the oil in a mill, and not merely stirred in by hand. While the use of red lead appears to be very general, its success depends so very much upon the care which the workmen take in preparing the surface to be painted, that it seems desirable that some paint should be found to take its place, which may be applied either to a hot or cold surface, and which should be ground in a vehicle rendered practically inert, so that it would not in itself tend to promote rusting already begun, or to start it on a surface where it had not already commenced. This vehicle, if it be possible, should be one which would be absolutely impervious to gases or moisture. With this idea, a well-known firm of paint manufacturers of this city, months ago, began a series of investigations into the subject, and, after many experiments, produced a paint which they have called "Anti-Rust."



BLAKE'S HIGH DUTY CROSS COMPOUND PUMPING ENGINE—DESIGNED AND BUILT BY THE GEO. F. BLAKE MANUFACTURING CO.

So far as the most careful experiments would seem to indicate, the vehicle, when dry, forms an absolutely impervious coating to gases and moisture. It has been prepared with three pigment bases: a brown oxide of iron, which is not highly recommended, as it is not the highest form of oxide, and might, perhaps, be subject to change; the bright red ferric oxide 98 per cent. pure, which some of the most eminent German authorities of the present day believe to be the most suitable pigment for painting iron, since it is practically unchangeable, and being itself iron, there can be no electric action between this and the metallic surface to which it is applied. The third pigment, and, in the judgment of Dr. Dudley, the best, is black, which seems to be chemically and electrically inert. Using this paint as an outer covering over a priming coat of pure red lead would probably give the best protection to iron, combining thus the advantages of both paint minerals.

One very important point in painting engineering constructions is the specification under which the work is done; too much care cannot be given to its proper preparation; the engineer should not only consider the scientific names of things, but what those things may mean in the trade. For example, he may specify iron oxide paint, red or brown, expecting to get the pure oxide. In the trade such a specification would indicate merely that he desired a paint material tinted red or brown with iron oxide, and would not show at all that he desired a pure pigment, unless it was so specifically stated. Unless he be thoroughly familiar with all the technical terms and trade designations, his best plan would be to consult a manufacturer on whose judgment and honesty he can rely, and by his aid draw up a suitable specification for the work on hand. It seems to me an entirely false view of the matter which induces some engineers and architects to refrain from specifying definite brands or makes of materials. When they know these to be good and feel certain that by specifying a certain brand they can insure for their client the employment of good and pure material, it then becomes their duty to do so.

THE BIGRAPH.

THE bigraph, invented by Marquis Louis Fonti, of Rome, permits of writing twice, and, although working with the right hand only, of obtaining simultaneously the original and a copy, as if the left hand also had been employed.

Doubtless we are not destitute of means of taking a copy of what we write, but, in passing them rapidly in review, we are going to show that none of them solves the problem that the inventor of the bigraph proposed to himself, and which may be enunciated thus: In writing a single time upon paper laid flat upon the table, and with ordinary ink, to obtain at the same time an absolutely exact copy of the original, so that the most practiced eye can make no distinction between the original traced by the hand and the copy traced by the apparatus.

The copying of letters, which will be done for a long time to come in offices, requires a special ink for the writing of the original, and a special thin and transparent paper for the copy, without speaking of the press and the brush for wetting the paper, that can happily be suppressed with the inks for copying without a press that commerce now offers us. With copying ink it requires great care to obtain a very clear copy without altering the original.

Afterward come the processes of reproduction that have the advantage of furnishing several copies of the original. But some, such as the *polycopy* apparatus, require that the original shall be written with thick and glutinous inks that are difficult to use. Moreover, the characters rapidly enlarge upon the gelatinous paste, and, after a few prints have been made, the copy only remotely resembles the original. The electric pens, mimeographs, etc., do not possess this inconvenience, but they furnish results only with a special writing, which does not offer that contrast of heavy and light strokes that pleases the eye in ordinary writing. The autocopyist, which has been so brilliant a success, requires an apprenticeship and a special manipulation for the stretching of the moistened parchment upon the frame and the maneuver of the inking roller, but it offers two valuable qualities to which its success has been due: the ink employed for writing the original is of perfect fluidity, and the copies are reproduced with printing ink, and are consequently unalterable.

In the case that we are examining at present, where a single copy is required, it is evident that none of these apparatus can be employed. Thus, for example, legal documents, which must be made in duplicate upon stamped paper and be written by hand, cannot be reproduced by any of the systems mentioned above. It is here that the role of the bigraph seems, on the contrary, to be indicated, Before describing it, let us recall the tentative made a few years ago by Mr. Levesque, who offered to the public, under the name of diplograph, an apparatus that permitted of obtaining two absolutely identical manuscript copies. The writer, sitting opposite the instrument, maneuvered two superposed penholders, rendered interdependent by a peculiar mounting. He could thus write each line in duplicate, the upper and the lower line each being received upon a distinct sheet of paper, and the upper sheet being folded by means of a special device.

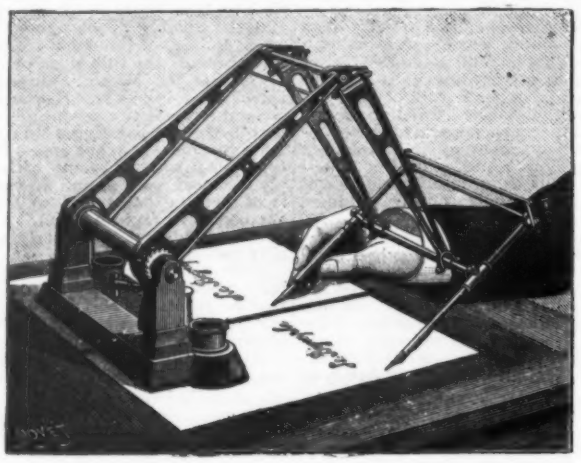
Mr. Fonti has solved the problem in a different manner. The paper, instead of being folded upon itself after each line is written, remains flat upon the table. The two sheets, juxtaposed, are held at the top by the base of the apparatus and at the bottom by a heavy flat metallic rule, not figured in the engraving. They must, in fact, be perfectly plane in order to obtain good results.

Two vertical supports forming part of the base receive the journals of the extremities of the horizontal axis. Upon this latter is placed a socket that supports the *ensemble* of the bigraph. A rigid rectangle connected with the socket carries at its extremity a rectangle of the same size, but provided with Cardan joints, thus permitting of its being converted into a parallelogram, the two lateral sides of which play the role of connecting rods. A second jointed parallelogram is suspended from these rods. The two lateral sides are formed by the sleeves of the two penholders, so that every motion communicated to the penholder to the right, which is held in the hand, is simultaneously reproduced by that to the left.

As to the other details of construction, our figure shows them so well that there is no need of describing them.

In front of the base there are two inkstands that have the same space between them as do the two penholders, so that when the writer dips his pen into the inkstand to the right, the penholder to the left enters of itself the stand that corresponds to it. After a regulation, which consists in causing the socket of the penholder to the left to advance or recede, so that its pen shall bear upon the paper with the same pressure as that to the right, and thus furnish lines of the same thickness, the apparatus is ready to work. The penman writes upon the sheet to the right without occupying himself with the one to the left, and the bigraph fills the latter with characters that are identical with those of its neighbor, whether it is a question of writing, pen drawing, music copying, or otherwise.

In order that the weight of the movable pieces may not tire the operator's hand, it is counterbalanced by a spring contained in the socket of the axis, and that is tautened more or less by means of a ratchet wheel. The whole, thus balanced, displaces itself with the same facility as an ordinary light penholder. To these various qualities we wish we could add that of cheapness, but the delicacy of its construction will make the bigraph quite a costly apparatus.



THE BIGRAPH.

The first model of the instrument was constructed by Mr. Demichel, of Paris, and it operates with mathematical precision.—*La Nature.*

BRIDGE OVER THE MISSISSIPPI AT MEMPHIS, TENNESSEE.

WE publish this week illustrations of the splendid bridge recently erected over the Mississippi at Memphis, Tennessee, to the designs of Mr. George S. Morison, of Chicago. We are indebted to *Engineering* for our illustrations and the following particulars:

The structure ranks in point of size as the third of its type in the world, its greatest span being 790 ft. 5 in., as compared with 820 ft. in the Sukkur Bridge, India, and 1,700 ft. in the case of the Forth. The following table shows some of the principal particulars of the bridge:

Span.	Length.	Weight of iron and steel.	Height.
	ft. in.	lb.	ft. in.
East of anchorage	101 0	66,700	Highest point to bottom of lower chord..... 80 6
Anchorage span..	225 10	1,608,000	
Channel "	790 5	4,690,300	Lowest chord to high water..... 75 4
Central "	621 0½	5,274,300	
West "	621 0¾	3,518,800	High water to low water..... 34 7
Deck "	338 9	1,073,000	
West viaduct.....	2260 7¼	3,306,600	Deepest foundation below low water..... 96 3
Total	4988 9	19,541,700	286 8

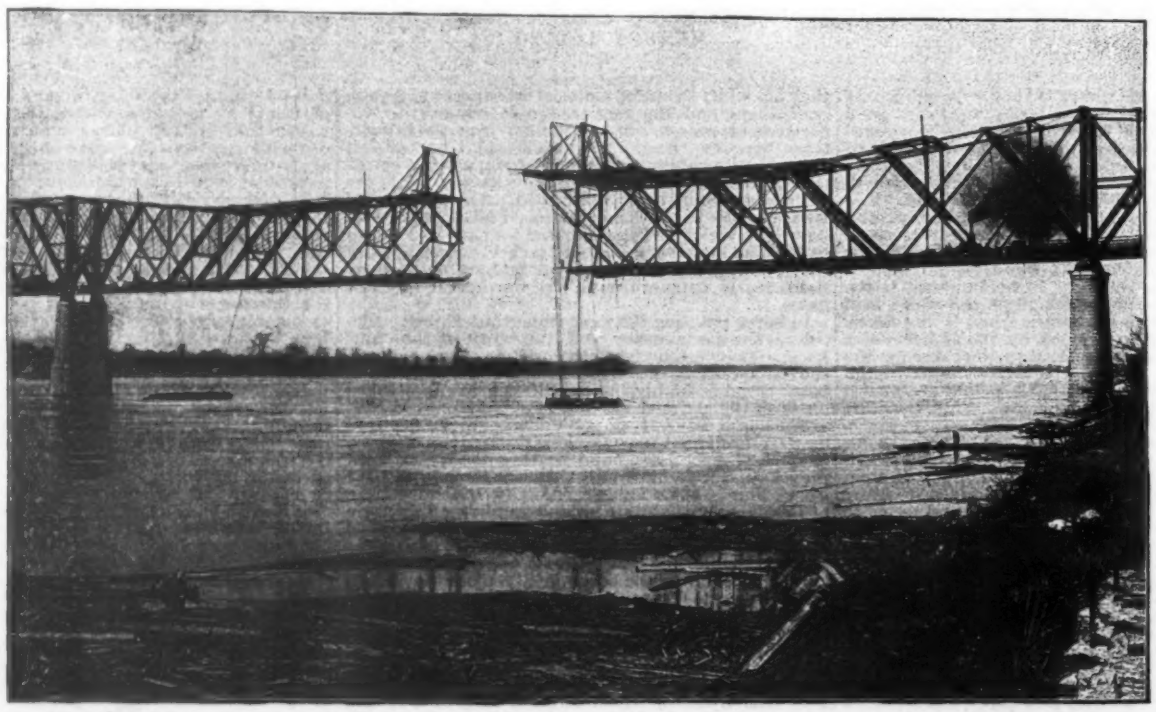


FIG. 1.—BRIDGE OVER THE RIVER MISSISSIPPI AT MEMPHIS, TENNESSEE.

Fig. 1 shows the method of building out the cantilevers. The material was brought up in barges and lifted into place by the gantries at the ends of the finished parts of the span. The method of erecting the shore spans on staging is shown in Fig. 2, while Fig. 3 shows some of the staging for the anchor span of one of the cantilevers and one of the shore piers. It will be noted that in this instance the staging is without diagonal bracing, a practice which, though not uncommon, cannot be recommended, and has led, quite recently, to some serious accidents.

The eastern end of the bridge, where there is an anchor span for the cantilever, rests on a rocky bluff, which is said to be that from which De Soto, the discoverer of the Mississippi, first gazed on its mighty waters. The western approach is over low lying marshy ground, requiring, as shown in the above table, a viaduct 2,290 ft. long. The cantilever span is over the deepest part of the stream, and is the second in order from the eastern shore. The whole of the river piers were sunk by the pneumatic process, the depth of the bottom of the curb varying, in different cases, from 43½ ft. to 96¼ ft. below low water mark, the latter being 34 ft. 7 in. below high water. The caissons, five in number, were, as usual, in American practice, built of timber, every stick used being cut to drawings furnished the timber merchants, and the work of construction was thus greatly lightened. The following figures show the dimensions of these caissons:

Pier 1.	Caisson	70 ft.	long,	30 ft.	wide,	51 ft.	high.
" 2	"	92	"	47	"	60	"
" 3	"	92	"	47	"	40	"
" 5	"	40	"	22	"	80	"

The bed of the river at the point where the bridge crosses consists of 40 ft. to 50 ft. of coarse sand, which is very subject to scour. To prevent such taking place round the caissons while they were being sunk, mattresses of willow and brush were first made and sunk on the site of the future pier. The caissons were then sunk on the bed thus formed, and the water being expelled from the air chambers, men were sent down who cut through the mattresses and began the work of sinking. The mattresses formed a perfect protection to the river bed, and no trouble was experienced from tilting of the caissons, which would otherwise have been likely to arise, owing to scour. When the sinking was completed, the mattresses were not removed, but left in position, riprap being thrown on them to form a further protection to the pier. The spoil from the working chamber was removed by forcing it up pipes. The greatest air pressure used was 47 lb. per square inch, at which the men worked in shifts of 45 minutes only, there being three shifts in the 24 hours. In spite of the care taken, four men died from caisson disease during the progress of the works. The whole of this work was done under the direct supervision of Mr. Morison and his representative, Mr. A. Noble, without the intervention of a contractor. The work was done very rapidly.

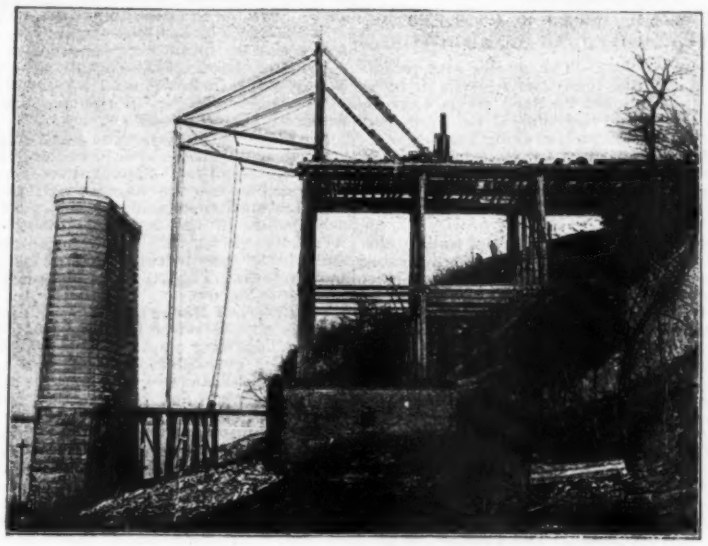


FIG. 3.—MEMPHIS BRIDGE.

The masonry portion of the piers varies in different cases from 93 ft. to 158 ft. in height. The masonry consists of a limestone backing, faced with granite, dimension stone being used throughout. The east abutment, to which the anchor arm of the cantilever is attached, is founded at a depth of 50 ft. below ground level and contains 2,500 tons of masonry. The following are the levels of various points of the piers, high water mark being 216·2 ft. and low water mark 181·6 ft.:

—	Pier 1.	Pier 2.	Pier 3.	Pier 4.	Pier 5.
Elevation cutting edge of caisson	137·85	88·09	85·39	132·94	124·98
Elevation top of caisson	190·09	147·29	135·01	173·38	204·98
Elevation top of masonry	283·17	283·17	283·17	283·17	241·91

Coming to the ironwork, it will be noted that the structure is pin-connected throughout. The trusses are spaced 30 ft. center to center, and the maximum height at any point is 77 ft. 7 13-16 in. between centers of pins. Steel was used almost exclusively, the exceptions being nuts, swivels and wall pedestal plates, for the former of which wrought iron was used, while the pedestal plates were of cast iron. Three different grades of steel were used, viz.: 1. High grade steel in all the principal truss members. 2. Medium steel in the floor system, laterals, portals, transverse bracing, and the latticing of the truss members. 3. Soft steel used only for rivets or at the option of the contractors in place of wrought iron, where the latter was specified. The steel had to satisfy the following laboratory tests:

—	High grade steel.	Medium steel.	Soft steel.
	lb. per sq. inch.	lb. per sq. inch.	lb. per sq. inch.
Tensile strength, maximum	78,500	72,500	63,000
" " minimum	69,000	64,000	55,000
Minimum elastic limit	40,000	37,000	30,000
	per cent.	per cent.	per cent.
" elongation in 8 in	18	22	28
" reduction at fracture	38	44	50

No punching was allowed in the case of the principal truss members, save as regards the lattice bars. In the case of the members of medium steel, punching was allowed, provided the holes were punched less than their finished size and reamed out afterward. The eye bars were specified to have their heads formed by upsetting. No welds were allowed. The heads were not to be more than 1-16 in. thicker than the body of the bar, and on test the bar was to break always in the shank and not in the head. Twenty full-sized bars were to be selected from time to time and tested to destruction in the large testing machine, Athens, Pa. Under these tests the bars were specified to develop an average stretch of 12 per cent. and a minimum of 10 per cent. before breaking, the stretch to be measured on a 20 ft. length, including the fracture. The elastic limit was specified to be not less than 32,000 lb. and the ultimate strength not less than 62,000 lb. The total amount of steel used, as shown by the table, was about 8,724 tons. The field riveting amounted, it is estimated, to about 100,000, which is, of course, a mere fraction of what it would have been in a riveted structure. With the exception of the cantilever span, all the spans were erected on false work. The cantilever arms are 169 ft. 4½ in. long, thus making the intermediate span 451 ft. 8 in. long. The expansion appliances are based on a range of temperature of 140° Fah.

DRAINAGE OF THE VALLEY OF MEXICO.

A CORRESPONDENT of the London *Engineer* writes as follows: The city of Mexico, though situated at a height of more than 7,000 ft. above sea level, is nevertheless in a valley, completely surrounded by hills. From this valley there is no natural outlet for the rain-

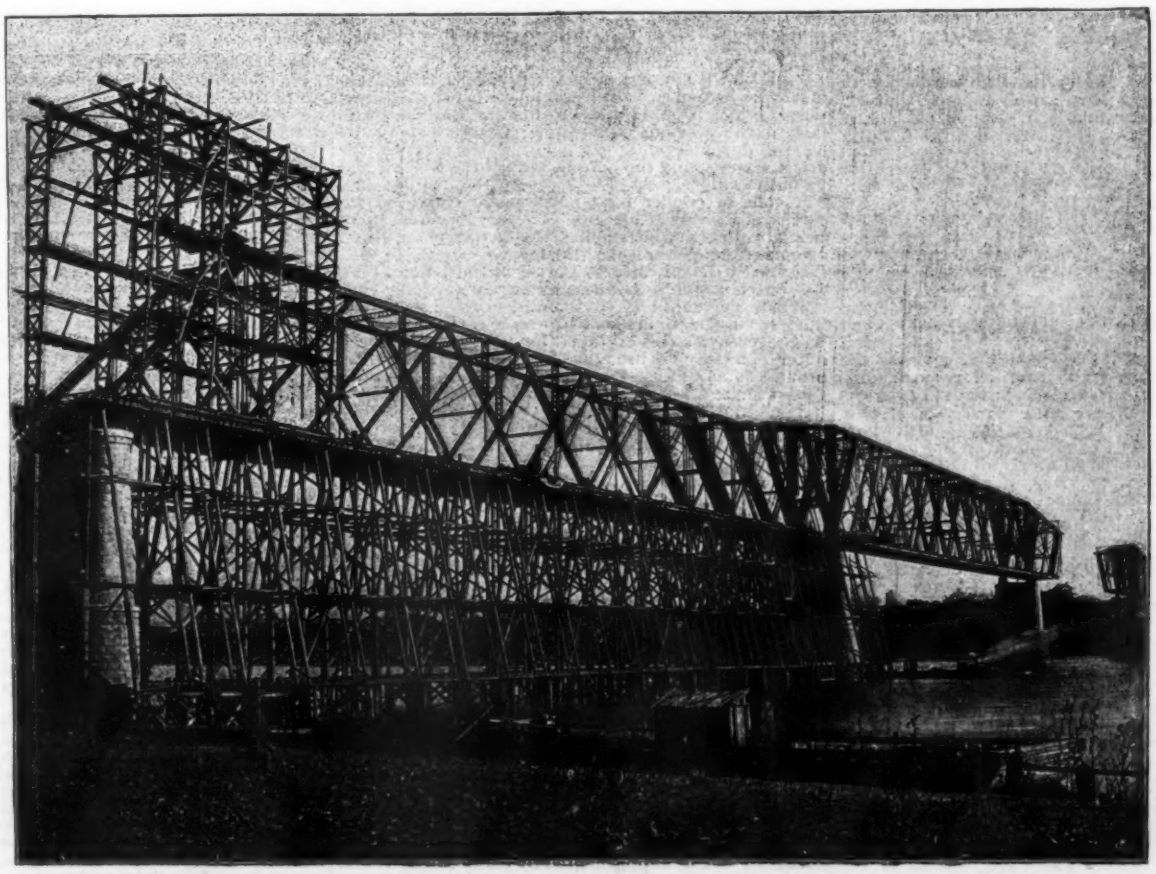


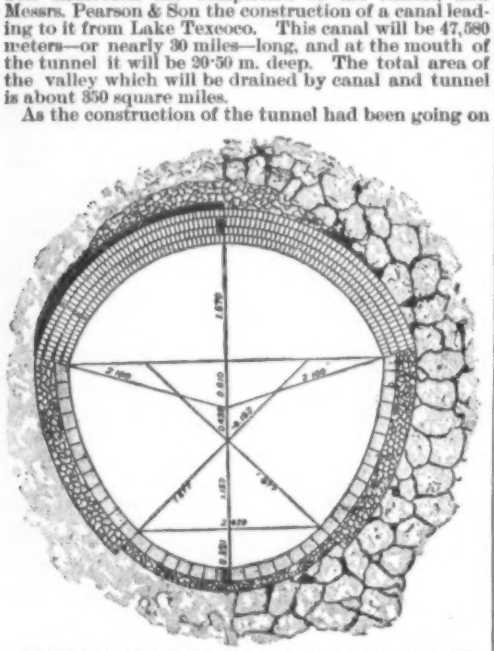
FIG. 2.—BRIDGE OVER THE RIVER MISSISSIPPI AT MEMPHIS, TENNESSEE.

water, and the drainage of the city and surrounding country flows into the Lakes Texcoco, Chalco, Xochimilco, Xaltocan, San Cristobal, and Zumpango. The first of these is the largest, being thirteen miles long by nine miles wide, and the average area of the six lakes is 200 square miles. The water level naturally varies with the rainfall, but is invariably higher than most of the ground in Mexico City, Lake Texcoco being usually about 4 ft. above the level of the Cathedral Square. All the city sewage has to be pumped up, and during heavy rains the pumps are not sufficiently powerful to carry off the surface water.

While Mexico was still under Spanish rule, it was decided that this could, and ought to be, remedied; and a cutting was commenced at Tequixquiac, on the further side of the range of hills which surround the city. For many years the work seems to have been abandoned; but about twenty-four years ago the Mexican government recommenced it, under the superintendence of French engineers. The cutting at Tequixquiac is opposite the lowest point in the hills bounding the Valley of Mexico, and the engineers determined to utilize it, and to carry the drainage to it, through the intervening high ground, by means of a tunnel. According to the original design, the tunnel was to have been oval in shape, 3·925 m. high by 4·017 m. wide, and to have had a length of 9·521 m., or about six miles. The present dimensions, as will be seen by the engraving, are 4·28 m. high by 4·18 m. wide (14 ft. ¼ in. by 13 ft. 8½ in.) The length has been increased, and will now be 10,020 m. During the next twenty years about 1,580 meters of tunnel were completed from the outlet end; the cutting was deepened, and in some places lined with masonry up to future high water mark; and twenty-five shafts, 400 m. apart, were commenced, and sunk to water level, or a few feet below.

In 1888 the government decided to ask for bids for finishing the work, and two contracts were eventually made, both with English firms. Messrs. Read & Campbell undertook the completion of the tunnel, and Messrs. Pearson & Son the construction of a canal leading to it from Lake Texcoco. This canal will be 47,580 meters—or nearly 30 miles—long, and at the mouth of the tunnel it will be 20·50 m. deep. The total area of the valley which will be drained by canal and tunnel is about 350 square miles.

As the construction of the tunnel had been going on



SECTION OF TUNNEL—MEXICAN VALLEY DRAINAGE.

for twenty years when Messrs. Read & Campbell took the contract, it might have been supposed that the government engineers would have been able to supply them with accurate data as to the quantity of water they would be likely to encounter. They estimated that the maximum at any shaft would not exceed 100 gallons per minute, and the contractors thought they would be on the safe side if they provided pumps with a capacity for three times that quantity. A short experience proved that these pumps were not large enough; in some cases even two effective pumps did not suffice to keep down the inflow, which occasionally reached 1,000 gallons per minute. Larger pumps were ordered from England, and the contractors continued the work as fast as they were able to make head against the vast volumes of water, till 1891. In that year a modification was made in the contract, whereby the drainage board relieved them of all responsibility with regard to the pumping, which is now being carried out at their expense, but under Messrs. Read & Campbell's supervision. The twenty-five shafts, which vary in depth from 93 m. to 28 m., are all finished, and work has been commenced on nearly all the faces. Up to the end of January, 6,000 m. of tunnel had been completed and another thousand meters of heading had been driven. At the present rate of progress the tunnel ought to be terminated by the autumn of next year.

The ground through which it is being driven is, as a rule, soft, and can be worked almost entirely with picks. In some parts it is of a hard compressed clayey sand, almost sandstone, known in Mexico as *tepitate;* but this disintegrates on exposure, and requires timbering as carefully as the softer material. In some places running sand has been met, and large quantities of water are found in almost every shaft. The arch is of four rings of brickwork, and the invert of concrete blocks, both being made on the ground. Large Hoffmann kilns have been erected, capable of turning out 30,000 bricks per day. The size is 9⅝ in. by 4⅝ in. by 2⅜ in., and they are of a better quality than can usually be obtained in Mexico. The majority of the concrete blocks measure 15¾ in. by 8 in. by 6 in. The moulds for these are made to the proper curves and lined with sheet iron, the concrete being rammed down as soon as they are filled. There is a backing of volcanic stone behind the blocks; and the same stone, a sort of red lava, is pulverized and used in the mortar with which both bricks and concrete blocks are set, the proportions being one part each of ground lava, lime, and sand. In each lineal meter of tunnel there are 20 cubic meters of excavation, 3·125 cm. brickwork in arch, 1·70 cm. concrete blocks, and 2·10 cm. backing.

The visitor from Mexico City travels by the Hidalgo Railway to the town of Zumpango, which is the headquarters of Mr. J. F. Toomer, Messrs. Read & Campbell's representative. From Zumpango a narrow-gauge line connects the different shafts, and about half way between the ends of the tunnel is the residence of Mr. F. W. Abbott, the engineer of the work, and also the fitting shops and foundry.

REYNOLDS' INSTRUCTIONS FOR ERECTING AND TESTING LIGHTNING CONDUCTORS.

1. *Position of Conductors.*—The angles and prominent features of a building being the most liable to be struck, lightning rods should be fixed on gable ends, chimneys, turrets, etc., and they should be connected together by continuous conductors along the ridges.

2. *Height and Spacing.*—Lightning rods should be about four feet high, and spaced at intervals not exceeding fifty feet, so that no point of the building is more than twenty-five feet horizontally from a lightning rod.

3. *Specification of Material.*—The metal to be exclusively employed for the construction of new lightning conductors is copper tape. A conductivity of at least ninety-five per cent. of that of pure copper should be specified; and the tape should be soft and flexible, so as to admit of its following closely the outlines of the building. Copper tape 1 in.×⅛ in., weighing about half a pound per foot run, is the most suitable size for all ordinary conductors, and 1½ in.×⅛ in. may be used for very high chimney shafts. In order that copper tape of long lengths, without joints, may be obtained, all future supplies for the use of this department will be obtained through the India Store Department.

4. *Protection from Theft.*—In situations where copper tape is liable to be stolen, it may be let into the walls of the building and cemented over, or otherwise concealed where it is accessible. The practice of protecting the lower portion of copper conductors on buildings by inclosing them in iron pipes at the base of the building is questionable.

5. *Earth Connections.*—In order to guard against those accidental defects and disarrangements to which conductors are liable, buildings provided with lightning conductors should have, as a rule, at least two earth connections, the conductors leading to them being connected at the base of the building either above the ground line or by a conductor under ground forming a "surface" earth.

Each lightning rod should be connected direct to earth by the shortest path outside the building, and, when practicable, it is well to carry the conductor down that face of the building which is most exposed to rain. In the case of gabled buildings, the conductor should be taken down the barge courses in preference to the gable, so as to protect the angle of the building.

6. *Earth Coils.*—When the level of water or permanently wet soil lies within a few feet of the surface, the conductors should terminate in earths offering each about eighteen square feet of external surface. These may consist of copper plates about 3 ft.×3 ft.×$\frac{1}{16}$ in., riveted to the ends of the conductors and buried in water or permanently wet soil from fifteen to twenty-five feet from the building. A better plan, however, is to coil the end of the conductor spirally on a wooden frame, the external diameter of the coil being four feet, with six-inch intervals between the turns. About thirty-three feet of tape is required for this earth connection; it obviates the necessity of any underground joint, taps a larger surface of earth, and, the tape being twice the thickness of the plate, it is more durable, besides being a cheaper arrangement.

7. *Wells.*—When the permanent water level is deep, it may be necessary to sink special wells for the earth plates, which should be of the same size as those specified in the previous paragraph. The wells should be carried down several feet below water level in the driest seasons, and the bottom part of the well should be built dry.

If coils of copper tape, however, be employed for earths, special wells are not necessary, because, there being no joints underground, the necessity for visual examination, periodically, no longer exists. In this case the earth coils may be buried at the bottom of a pit sunk below the level of permanently wet soil.

Where the depth is considerable, two or more conductors may be connected to the same earth plate, and, in the case of a coil of tape, the inner as well as the outer end may be brought up to the surface of the ground so as to form two earth connections. In both cases the size of earths should be made proportionately larger.

8. *Surface Earths.*—In addition to these deep earths, it is necessary to provide surface earths laid in trenches from one foot deep in clay soils to two feet deep in sand or shingle, through which the rain percolates more freely.

These surface earths may consist of that portion of the conductor which leads from the base of the building to the well or deep earth, or they may be arranged as separate conductors led in trenches away from the building. In the latter case the deep and surface earths should be connected together with a conductor carried round the base of the building.

The length of each surface-earth trench may be from twenty-five feet in ordinary soil to fifty feet in dry soil, and the width at bottom should be about nine inches. A few inches of powdered charcoal should be spread both above and below the conductor, and the trench filled in with light soil. Any rain water down pipes may, with advantage, be led into these trenches.

9. *Sea Earths.*—In the case of buildings near the sea good earths can be obtained by laying a length of tape so that at least five square feet of it shall always be under water; or a coil of tape may be buried in permanently wet sand.

When the distance to the sea is considerable, these earths should be supplemented by surface ones round the building, so as efficiently to tap any induced charge in its vicinity.

10. *Iron Pipes.*—Iron water pipes, etc., form good earth connections. Soft metal pipes and gas pipes should not be used, but, when they run close to the conductors from a building, they should be connected to the lightning conductor or system. There are many recorded instances in which both water and gas pipes have been damaged by lightning springing on to them from neighboring conductors, which would have been obviated if they had been connected thereto.

11. *Dry and Rocky Sites.*—In extremely dry or rocky situations it is almost impossible to obtain good earth connections, except at a great distance. In such cases the best plan to adopt is to bury several hundred weight of old iron at the foot of the earth coil or plate in the mass of coke or charcoal, leading any rain water pipes or drains so as to discharge into it.

12. *Coke, Charcoal, etc.*—Coke, charcoal, or smith's ashes will be found very suitable for improving the earth connections of lightning conductors. A layer of about three inches should be spread both below and above the conductors in the trenches, and also round the earth plates or coils.

13. *Flagstaff Earths.*—The earth connections of flagstaffs near magazines should be led in a direction away from the building. Should, however, the horizontal distance between the flagstaff and the nearest lightning rod on the magazine be within fifty feet, or should any portion of the building be within the cone protected by the flagstaff rod, then the magazine and flagstaff earths may be connected, or have an earth common to both. This rule is also applicable to shafts of powder mills, etc.

14. *External Masses of Metal.*—Rain water pipes and gutters should never be utilized as a portion of a system of lightning conductors, to which, however, they should be connected. All external masses of metal, such as copper sheeting on magazine doors and ventilators, etc., should also be connected to the nearest conductors by lengths of copper tape.

In the construction of magazines and other buildings in which the manipulation of explosives is carried on, the employment of external masses of the metal should be avoided as far as possible.

15. *Lines of Rail, etc.*—Lines of rail near buildings protected by lightning rods should be connected to earth direct on both sides of the building, and when the line is carried inside the building it should be connected also to the system of lightning conductors. Iron railings round magazines should be connected direct to earth at intervals of about fifty feet.

16. *Internal Masses of Metal.*—All large and long masses of metal, such as beams, girders, pipes, water systems, and large ventilators fixed in the interior of the buildings, should be electrically connected with the earth as well as with the conductor; but soft metal gas pipes should never be used as conductors, and the lightning conductor should be kept as far as possible from them, and also from all internal gas pipes.

17. *Fixing Conductors.*—Lightning conductors should not be insulated from the buildings to which they are attached. The copper tape should be laid on the ridges and walls, and secured by suitable fastenings screwed or nailed to the building. The holdfast should be of copper or gun metal, fixed by nails or screws of hard copper; and they should allow for expansion and contraction, at the same time preventing all the weight falling on any one bearing.

18. *Metal Roofs.*—Buildings with zinc or galvanized roofs should be protected by copper conductors laid over them, but protected from actual contact by strips of wood, paint or tarred felt. The zinc roof itself should be treated like any other external mass of metal, and should be thoroughly well connected to the conductors in several places. The system, sometimes adopted, of having sheet zinc lightning rods and copper tapes from the eaves of the roofs to earth is very unreliable, because the lightning rods are of ineffective section, the zinc sheets are isolated from one another by a layer of oxide, and the joint between the zinc and copper is liable to failure.

19. *Chimney Shafts.*—Chimney shafts should be protected by a ring of copper tape 1⅛″ × $\frac{3}{16}$″, placed round the outside of the top of the cap and a few inches below it, having stout copper points projecting one foot above the top of the shaft at intervals of two or three feet all round. Copper tapes should be carried down on opposite sides of the shaft to earth from the ring; and these conductors should be connected at the base, a test joint being added to enable the continuity of the conductors and the state of the earth connections to be ascertained when necessary.

20. *Joints in Conductors.*—Metallic continuity should be insured at the joints of all conductors. The conductor should, therefore, if possible, be made up in one continuous piece, of the proper length, before it is sent out to be erected. The joints between copper tapes should be made by close riveting and should be carefully brazed and painted over. When brazing is impracticable, as when it is necessary to make a joint *in situ*, the joint should be riveted as before and embedded in a mass of solder. In riveting copper plates, five rivets should be used, and the holes should be bored, not punched; the "arris" being removed and the surfaces brightened with emery, the joint should be brought together with a hollow punch before riveting.

21. *Joint between Lightning Rod and Conductor.*—The connection between the lightning rod and the conductor should be made by means of a slotted clamp similar in design to those employed for tests and other joints. The lightning rod should terminate at its lower extremity with a ¾″ bolt, screwed into the clamp, and thereby making firm contact with one or more tapes inside it. The conductor should also be brazed or soldered to the clamp as described in the preceding paragraph. The lightning rod should, if possible, be sent out connected up with the conductor, ready for fixing.

22. *Repair of Old Conductors.*—For the repair of old lightning conductors, however, it may sometimes be necessary to use solder. For copper, the solder usually employed consists of equal parts of tin and lead, which has a resistance nearly ten times that of copper. The surface of the joint should, therefore, be not less than 1¼ square inches.

Molten zinc should be used for soldering iron conductors. Being nearly twice as conductive as iron, the surface of the joint need not necessarily exceed that of the cross section of the conductor.

In both cases, the joint should be put together previously by screws or rivets, and the soldered joint, especially in underground work, should be carefully protected from galvanic action by tarred tape.

23. *Connecting Wire Rope to Copper Tape.*—Existing iron wire rope conductors may be connected to copper tapes in the following manner: Take a piece of sheet copper 4½"×3"×⅛", and have one side tinned; cut it down at one end to the size of the tape for a length of 1½", and rivet the tape to the sheet at this part; then bend the remainder of the sheet round the end of the rope, which should have been previously frapped with fine wire, thus forming a tube with the tinned side inward. Sweat up the joint with zinc solder, and protect it by tarred tape bound tightly over it.

24. *Connection to Iron Water Pipes.*—Copper tape conductors may be connected to iron water pipes laid underground by filing about a foot of the top of the pipe bright, binding the tape onto it by wire, and soldering with zinc; or a short length of iron bar 2"×⅛" may be riveted and soldered to the copper tape, and then bolted to the flange of the pipe by ½" screws passing through both the bar and the flange.

It is a good plan to coil several turns of the copper tape round the pipe (keeping it from actual contact by slips of wood) previous to fastening the end, so as to increase the earth connection should the joint ultimately fail. The greatest care must in all cases be taken to protect the joint from galvanic action, by layers of tarred rope, or by embedding the joint in cement.

25. *Expansion of Conductor.*—The variations of temperature produce an expansion and contraction in copper conductors which should be provided for by allowing the conductor free play through the hold-fasts employed to fix it to the building, and by leaving a small loop of the tape in some portion of its length. Conductors should never be screwed or nailed down. Vertical conductors on shafts, flagstaffs or high walls should have small loops above every second or third hold-fast, to take the weight off the conductor while still allowing for expansion and contraction. The hold-fasts in this case should be about four feet apart.

26. *Conductors not to be tampered with.*—In carrying out repairs to buildings, maistries and coolies must be specially warned never, under any circumstances, to disconnect, move or tamper with any portion of a lightning conductor unless specially ordered to do so, and then only under the supervision of the officer in charge of the work.

27. *Records of Conductors.*—Records of all lightning conductors should be kept in every divisional office, and should contain as many of the following particulars as possible:

(*a*) Date of erection or reconstruction.

(*b*) Character of soil or sub-strata, and depth of permanent water level or wet soil.

(*c*) Full particulars of lightning rods, conductors and earth connections, nature of joints and connections, etc.

(*d*) Details of all external or internal masses of metal entering into the construction of the building and how connected to conductors.

(*e*) Positions of test joints, if any. Nearest earth available for testing, etc.

(*f*) In case of magazines, etc., quantity of powder, etc., usually kept in store.

(*g*) Date of last inspection, and *précis* of former tests, suggestions, etc., of inspecting officer.

(*h*) In case of buildings not under the immediate charge of the Public Works department, name or title of person to whom notice of inspection should be sent.

28. *Periodical Inspection.*—Lightning conductors should be inspected and tested once a year, and a report drawn up showing the result of such inspection.

29. *Electrical Tests.*—The object of electrical tests of lightning conductors is to determine the resistance of the earth connections and to localize the position of any defective joints or connections in the conductors. The resistance of a conductor itself is quite inappreciable (less than ¼ ohm per 1,000 yards for copper tapes 1"×⅛"), and cannot be detected by the testing apparatus usually employed. The resistance of the earth depends on the nature of the soil and its state of moisture at the time of test. As a rough guide, however, it may be mentioned that the joint resistance of two earths such as those described in paragraph 6, thirty yards apart in wet soil, will not exceed two ohms, and the greatest resistance offered by any earth must not exceed ten ohms.

30. *Defective Joints Localized.*—The resistance of the conductors from summit to ground line, or to that part of the conductor from which the resistance of the earth connections is ascertained, should, therefore, be practically *nil*. Any resistance in excess of that of the battery and leads must be due to defective joints, and the faults should be localized and marked for repair; and to enable this to be done, test joints should be added to all conductors.

31. *Conductors Made in Short Lengths.*—Conductors made in short lengths and connected by joints must have their metallic continuity insured by soldering or a good system of riveting, and the joints, when tested electrically, must give no resistance. Underground joints and earths the nature of which is not known should be dug up and examined when practicable.

32. *Test Joints.*—Where the system of lightning conductors has more than one earth connection, it is necessary to introduce test joints to enable the resistance of each earth connection to be ascertained separately. These joints consist of a slotted clamp to which the two portions of the tape are attached by bolts.

Where the cross connections between conductors or external masses of metal are few, these joints can be inserted in these cross connections; but where the system of conductors is complicated, they must be placed on the conductors themselves, the object to be kept in view being that by means of the test joints it shall be possible to isolate each earth separately for purposes of testing.

They must, therefore, be placed in convenient positions, so that the conductor can be disconnected without difficulty when required.

After the tests have been completed, the test joints must be carefully re-made, the contact surfaces thoroughly cleaned with emery and brought into intimate contact with the bolts. The joint should then be covered with waterproof tape and painted over. When the joint is completed it should be tested for metallic continuity. A space should be formed or left behind the joint to allow the tape to be passed round the conductor.

Single conductors without cross connections to metal down pipes or gas or water pipes do not need test joints.

33. *Test Leads.*—In order to test the continuity of conductors fixed to inaccessible places, such as flagstaffs, chimneys or steeples, an insulated test lead must be led up the flagstaffs or other erection, and at its upper extremity attached and soldered securely to the lightning rod above its junction with the conductor. This lead should be of Hooper's core, metal (lead) covered, resistance not to exceed ten ohms per mile.

34. All lightning conductors on public buildings should be brought, as far as possible, into conformity with these rules; but existing arrangements may generally be allowed to stand, provided care be taken to improve defective earth connections and to make good all joints.—*Indian Engineering.*

A PHOTOGRAPHER'S ELECTRIC PENCIL.

THIS pencil is used by photographers for dodging or retouching photographic negatives.

In retouching the defective lines or spots on a negative, the stroke of the pencil requires in many cases, in fact in almost every case, to be minutely small, and therefore to obtain the desired effect is a very slow process, as these small strokes have to be made with great care.

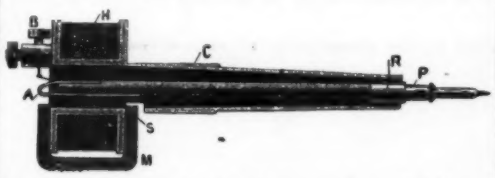
Recently an American firm introduced a pencil which is rapidly revolved by a small electromotor so that the point of the pencil spins, and thereby is rubbed on to any spot by simply moving the point gently over it in any desired direction, thus doing away with the necessity for the tiresome confined motion of the operator's hand.

Another method and apparatus also recently introduced from Germany consists in fixing the negative in a frame, which is vibrated rapidly by an electro-magnetic apparatus.

The appliance herein illustrated is a British production, and in it the pencil point is very rapidly vibrated through an exceedingly small stroke by a simple electro-magnetic contact breaker, so that the pencil has only to be guided by the operator while the electro-magnet performs the necessary rubbing at an exceedingly rapid rate, about 2,000 strokes per minute.

It is claimed that this form is simpler and less liable to derangement than the rotating form.

A battery of two large Leclanche cells works this vibratory pencil, and where a number are in use one contact breaker can be arranged to work them all. Referring to figure, P is the pencil pivoted at R in



trunnions; C is an ebonite case carrying a bobbin of fine wire; H, B is the contact breaker platinum screw point; A is the armature, a light piece of soft iron passing through coil; M is a piece of soft iron fixed outside of the coil to which the armature is attracted. A spring, S, opposes the attraction and sends back the armature, which is fixed on the end of the pencil. It will be readily seen that the pencil point makes a small motion compared with the play of the armature.—*Electrical Review.*

PHOTOGRAPHING INTERIORS.

By ELLERSLIE WALLACE.

INTERIOR photographing, while very much easier at the present time than it formerly was, still ranks as a difficult branch of the art.

In earlier days, when plates were not as sensitive as they now are, the chief bugbear was the want of light in interiors of various kinds. While capital results could be obtained on collodion plates when the interiors of spacious buildings like the great European cathedrals were attempted, other kinds of interior work, such as the parlors of private residences, studios, halls and bedrooms, were precluded entirely. Many interiors of the latter kind were indeed well lighted in the sense of admitting the sunlight in large quantities, but no use could be made of it when photographing. Unless the blinds and shades in the room were drawn down, the illumination became so unequal and patchy that failure was certain. Consequently, when the sun was thus shut out, the interior became very dark, and in numerous cases photography became quite impossible.

Although modern appliances have greatly changed things for the better in this respect, the same old difficulties are still often met with, and the knowledge and ingenuity of the photographer will be taxed heavily sometimes to produce presentable results in this kind of work.

It goes without saying that any interior to which daylight can be admitted can be photographed, but the question will often arise whether it is better to use daylight alone or to resort to the magnesium light as an assistant. Cases sometimes arise in which the daylight is admitted from only one point at either end or side of the apartment, and when, in order to secure the best view and obtain the best perspective, the camera must be so situated that the lens faces the light. This is a very unfortunate state of affairs, for, apart from the unavoidable solarization of the windows admitting the light, the shaded sides of all the principal objects face the lens and make it difficult to obtain the necessary detail, while any light-colored objects will be over-exposed. I should always be in favor of using the magnesium flash-light, in addition to what daylight could be secured by covering the window with white paper, in an apartment of this description, if the camera had to face the light. One or more charges of the powder can be fired from some suitable position near the camera and give sufficient lighting to all those shaded sides of objects which receive no light from the window, while the crudely defined shadows of table legs, etc., which might show if the flash-light were used alone, will be done away with by the soft daylight entering through the window. It will often, however, be advisable to depend entirely upon the artificial light. Supposing that there are windows at the end of the room facing the camera, the blinds are to be tightly drawn. The charge having been fired, the lens is capped and the blinds of the windows opened again. Returning to the camera, the operator uncaps the lens for a second or two, or until the image of the window with its curtains or draperies has time to just make an impression on the film without solarizing, and before the smoke of the magnesium has time to settle down and fog the view. One important thing must be borne in mind, which is to see, before fixing the charge, that there is no looking-glass or large framed picture in such a position that the intense light of setting off the charge is reflected back into the lens. Sometimes, indeed, this unpleasant *contretemps* cannot be avoided, and it is impossible to cover the reflecting surfaces with cloths or paper. In such cases all that can be done is to make the exposure in the regular way and lay the negative aside for careful treatment by the retoucher afterward. If for any reason it be preferred not to scrape away entirely that portion of the film which corresponds to the mirror or picture frame, an application of ferricyanide of potassium may be made to the dry film with a small camel's-hair brush, and repeated until the density is sufficiently reduced.

One undoubted advantage of the artificial light is that it illuminates well the upper corners of the room at the ceiling and brings out detail in the negative which would be wanting entirely if daylight alone were depended upon.

It is no more than natural that persons should desire themselves or members of their families or friends photographed in their own rooms with the familiar surroundings. Admirable as the magnesium light is in other respects, the very fact that it makes such a desire possible will, at times, give the photographer a great deal of trouble. I do not wish to consume space here in giving directions how to pose groups for night photographing, but I must ask the readers of the *Bulletin* to remember that there is a great difference between figures introduced into an interior, simply as accessories to the surroundings, and groups or single sittings regularly posed for the camera. The drawback to flash-light portraiture has always been that, unless special care is taken, the face of the sitter will be corpse-like, with the eyes dilated and staring. It may be well to call to mind here that the actinic impression from the discharge is actually made upon the sensitive film before the pupil of the eye has time to contract at the bright light. All flash-light portraits present this interesting peculiarity. Therefore, if people insist upon being taken themselves, or having their friends taken in their own rooms, this fact should not be forgotten, and full-face or three-quarter positions of the sitter avoided, so as not to show the eyes more than possible. It is a curious thing in this connection that colored people photograph better with the flash-light than white ones. In looking over a volume of very fine interiors recently made by one of our well-known photographers, I was surprised at the life-like and natural appearance of some colored waiters who were grouped around a richly loaded wedding table in readiness for the guests. Every detail of the interior with the glass and china on the table was perfectly rendered.

It is hardly necessary for me to caution photographers about handling the magnesium light. As the flame of the discharge is very large, of course it will not do to fire it off underneath or too close to curtains or lambrequins. But it might be well to mention to the owner of the house that there is sure to be some white smoke after the firing, and that the windows will have to be opened to get rid of it. It will never do to be parsimonious about the quantity of magnesium used—better too much than too little, which would give an under-timed plate.

The photographing of large interiors, such as public halls, railway stations, etc., is easier than when the space is so much confined before the camera that wide angle lenses have to be used. Finely executed photographs of living rooms and other small apartments are now often to be seen, but the good effect is frequently marred by the violent and distorted perspective inseparable from the wide angle included. This is, indeed, the principal difficulty with small interiors. It is indispensably necessary that enough subject be included to make the picture recognizable, and this can only be done by resorting to a wide-angle lens. The consequence is that the distant portions of the room appear far too small in the picture, while pieces of furniture near the camera are so absurdly enlarged that one might think the photograph had been taken simply for the sake of the chairs or tables. Rugs or squares of carpet appear like huge triangles dwindling off into narrow strips at the remote parts of the room. Picture frames and mirrors look like the obtuse-angled quadrilateral figures seen in works on geometry, while the floor and ceiling are steep-pitched like the roof of a house. But where there is plenty of room in front of the lens, as, for instance, in a large museum or factory, none of these defects need be present, since the photographer is free to move back as far as he pleases and use a lens to suit the subject. These large halls also frequently have balconies or other means by which the operator can make the view at a sufficient elevation above the floor to get rid of objects close in the foreground, which would greatly injure the picture, no matter whether a narrow or wide-angle lens were used.

In fact it is a cardinal principle in interior photographing to pay special attention to foreground objects. Supposing a small dining-room in a private apartment were to be taken, it would help matters a good deal sometimes if the table were shifted away from its central position in the room toward one of the corners and the glass and china upon it arranged so as not to crowd the corner nearest the camera. In like manner a little judicious rearrangement of the

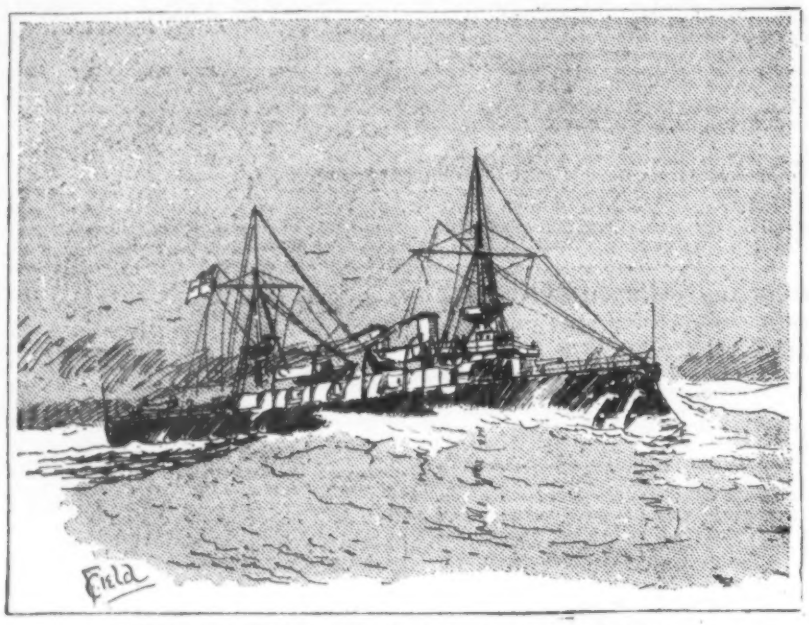
furniture in almost any small room will aid the pictorial effect by getting rid of ottomans, chairs, small tables or stands that would come out by far too large in the negative.

There are really no directions that I need give about the photographic part of the matter, but, in concluding, I must again urge the importance of attending to the lighting and to the arrangement of the foreground objects. I need hardly say that single landscape lenses which give curved lines at the sides of the picture should not be used for this sort of work.

Multiple-coated plates, which are now attracting so much attention, will give good results, provided they are handled just right. They seem to stand any amount of over-exposure without solarizing. I should not be inclined for the present, at least, to recommend them for interiors when it is comparatively easy to succeed with ordinary plates. The theories involved in the making of these plates are ingenious, and the near future will prove whether they are to be relied upon in preference to the ordinary kind.—*Anthony's Bulletin.*

H. M. S. AUSTRALIA.

AMONG the British contingent in the great naval display in honor of the discovery of America, in Hampton Roads and New York harbor, will be the belted cruiser Australia, which has for some time past belonged to the Mediterranean fleet. The Australia has been ordered home, but will go out of her way to New York. She is one of seven sister ships, all useful vessels, but nothing in comparison with some of our other cruisers. The class comprises the Orlando, Undaunted, Narcissus, Aurora, Immortalité, Galatea and the Australia. They have armor belts and carry two 22-ton B. L. guns, ten 6-inch guns, besides a number of quick-firing and machine guns.—*London Daily Graphic.*



THE BRITISH WAR SHIP AUSTRALIA.

THE EFFECTS OF A COLLISION.

WE give a photographic illustration of the appearance of the steamer H. M. Whitney after her collision with the steamer Ottoman in Boston harbor. The accident took place several months ago. The frightful rent in the Whitney's side shows an apparent weakness of construction.

Within the past few weeks one of the largest and strongest of the ocean steamers plying between New York and Liverpool, the Naronic, of the White Star line, has become missing, and all hope of the safety of the ship or crew is abandoned. She was a freight boat of some 6,000 tons displacement, and her loss is unaccountable, except upon the supposition of some such casualty as a collision with an iceberg or a floating wreck or other vessel. How suddenly the Naronic might have gone down from either of these causes our picture readily shows.

We illustrated a few years ago the collision of the ocean passenger steamer Arizona, plying from Liverpool to New York. She ran at full speed, head on, upon the shelving part of a great iceberg. Her bow was terribly smashed up; but otherwise she was uninjured, and safely steamed into the harbor of St. Johns, N. F., having been saved by the strength of the bulkhead of her fore compartment. The engraving and description of this remarkable occurrence will be found in SUPPLEMENT 210, January 10, 1880.

WALL PAPERS.*

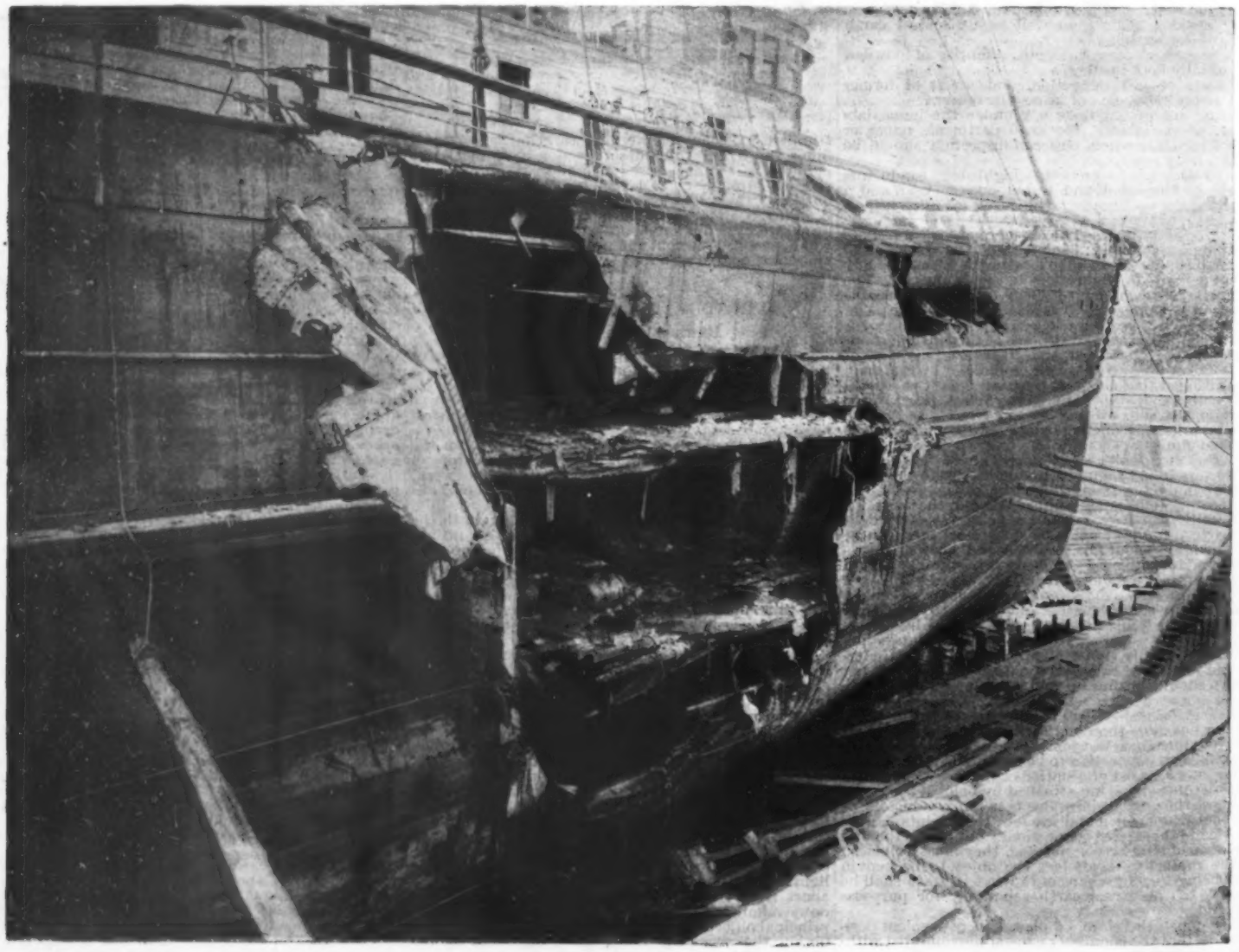
By T. R. SPENCE.

THE first record of the manufacture of paper hangings in England dates from the year 1692, as a patent was taken out at that date by a William Bayley, who stated that his invention consisted of "several engines made of brass," for the printing of all sorts of paper, of all sorts of figures and colors whatsoever, and that "the said invention had not been heretofore known or practiced by any of our subjects." There is no doubt the first attempts were the imitation of tapestry, linen or other hangings that were at that time fashionable. In the reign of Queen Anne, 1712, a duty was imposed on paper hangings. They were made on pieces, 16 to 24 sheets, forming about 8 square yards; each sheet bore the government stamp; the duty was 1¾d. per square yard. Paper stainers were required to pay an annual license of £4.

In the reign of Queen Anne paper hangings were imported from China. Probably the first idea of their manufacture here was suggested by these importations. In 1746 larger blocks were used for wall paper printings, some two yards long, made from light material, but these were soon found unsuitable and were replaced by heavier and shorter blocks.

In 1753 Edward Deighton used engraved metal plates in a rolling mill. The designs were afterward colored by hand; gilding of parts was also introduced by him—doubtless suggested by the gilded leathers used in the 16th century—for wall covering. A man named Jackson, about this time, made and sold papers in imitation of statues, landscapes, etc., and quaintly remarks

* A recent lecture before the Society of Arts, London. From the *Journal*



STEAMER H. M. WHITNEY AFTER COLLISION WITH STEAMER OTTOMAN, BOSTON HARBOR.

that "the persons who cannot purchase the statues themselves may have these prints in their places, and thus effectually shews his taste." Whether his cheap antiques "caught on" I am unable to say. In a work printed by J. Nourse, in 1764, it is stated that there were three methods in use, namely, printing in colors, using the stencil and painting with a pencil or brush. These processes are described at some length, and approached the block printing now in use. Stenciling was found to be cheaper, but not so sharp as blocks. The pencil was used for finishing and adding further details.

Flock printing was also described as giving faithful imitations of silks, velvet, damask, etc. A piece of paper was taken off the walls of a mansion near Whitehaven in 1786; it was asserted that it had been there about 200 years. Its thickness was that of cardboard, and had evidently been fixed to the wall with varnish. The ornament had been stenciled and afterward finished by hand.

Sherringham, of London, in 1786, as the result of journeys to the Continent, made great advances in the art of paper staining.

Anthony G. Eckhardt, in 1792, made papers from engraved copper plates and decorated them with silver and gold leaf. This gilding was the invention of John Hautch, of Nuremberg, about the middle of the 17th century. It was a preparation of tin and copper, and is now commonly known by the name of Dutch metal. Eckhardt also printed on stiffened linen, finishing by gilding and varnishing, and employing artists of considerable skill.

In 1796 T. G. Hawcock was the first to introduce embossed paper.

In the picture galleries at Hampton Court Palace

GUN DRILL IN THE UPPER ALPS—ITALIAN ARMY CORPS.

are the remains of wall papers which are asserted to date from the time of Charles I. There are, or were, some old flock papers on the walls of King William's bed room, dressing room and writing room. The date of their production I cannot state. They may not be very old, as the patterns are like the patterns used 50 years ago. Paper hangings 50 years ago were made of several sheets, 23 × 28, fixed together in lengths of 12 yards.

Lewis Robert, a French workman, in 1799 made a machine for producing paper in endless pieces, and in 1803 John Gamble obtained a patent in England for making paper in endless sheets.

In 1836 the reduction of the duty gave a great impetus to wall paper manufacture, with the result that its use was very much increased. In 1861 the duty was altogether abolished.

The first process in wall paper manufacture is the preparation of the design. This, as a rule, is sketched out roughly, sometimes on a small scale, but more frequently plotted out to the actual size necessary for the rollers or blocks in which it is to be cut. The usual area for roller printing is 21 inches by 21 inches; block printing gives a more extended surface, varying from 21 inches by 24 inches to 24 inches by 36 inches. On these areas the artist has to express himself as best he may, for the design must necessarily repeat itself correctly in these spaces. Should the designer be dowered with redundant imagery, these inexorable limitations become a tyranny and a chilling frost on his dreams.

It is well to work on a piece of paper 6 inches larger all round than your 21 inches by 21 inches. In the middle of this allotted space, the design may be roughly sketched, running out certain large general sweeping lines across and into the outer spaces. The general purpose and direction of such lines the designer will have in his mind's eye, and if he is a fairly skillful draughtsman, he may come very near the correct points on the edge of the space necessary for the repetition of his pattern. Unless the designer's conception first lives in his mental vision, it will not come by any fishing process or without previous thought or creation.

This rough design is roughly traced and placed at the sides, top and bottom, so that the curves or other detail shall work out the correct repetition of the pattern. There are certain rules for working out in geometric patterns, but they are too complicated for present description. Some prefer to get the pattern in somewhat of a muddle, as the process of unraveling stimulates mental effort and invention—to fill up undeveloped spaces—thus obtaining more interest and thought in the detail.

When the whole design is complete in outline, it is transferred to a sheet of paper of the tint that is to predominate in your color scheme; on this are laid the various colors in distemper as shall be used for subsequent printing. The design is carefully traced and transferred to rollers or blocks, which are destined to print the pattern on the paper.

These rollers have to be prepared with great care, and to be of thoroughly seasoned sycamore. All outlines of flowers, grounds, etc., are formed by driving into the wood, up to a gauge, copper slips and the intervening spaces filled with felt, thus forming the printing surfaces. Sometimes the rollers are covered with paper ⅛ inch thick, and the copper slips are hammered through into the wood, the paper acting as gauge. The paper is picked out and the spaces fitted with felt. The copper bordering keeps the whole design sharp and permanent. The edges formed by the incised printing pattern, if of wood only, soon become ragged and worn.

Each color requires a separate roller, and when attempts are made to imitate the colors and gradations of natural flowers, it is no uncommon thing to have 20 separate rollers.

The enormous cost of cutting 20 rollers for the printing of one paper should be the means of opening our eyes to the fact that, if wall papers are to conform to the best traditions of decorative art, such a multiplicity of tints can never be satisfactory. All fine decoration is simple, and of a limited scale of tints and gradations. Manufacturers now, in employing designers, generally stipulate a limited number of printings, on the score of expense of production. They thus, shall I say unconsciously, are furthering the best decorative ends, remembering that wall paper is an adjunct, within the reach of moderate means only, not the whole end and ideal of decorative art.

For roller printing, the rollers are very accurately mounted on a large revolving cylinder, the latest type of cylinder being capable of carrying 16 printing rollers, thus, at each revolution, turning out a paper containing 16 printings. The paper is first carried from a smaller supply machine, which regulates the supply and tension of the material against the rollers, these being supplied with the necessary printing tints from an endless blanket roller, revolving through troughs of color. When the paper has received its printed pattern, it still further travels over a succession of rollers, through the drying room; when perfectly dry, it is transferred to a machine for cutting into lengths of twelve yards. A machine carrying two rollers produces paper at the rate of about four miles an hour.

In the blocks which are to be used for the hand printing of wall papers, the design is first traced upon the block, and the portions which are not to be printed are cut away, leaving the design, as originally traced, in relief, and this relief surface, of course, takes the color from the color blanket, and that, with lever pressure, transfers itself to the paper. Occasionally, however, where the lines in the drawing are very fine, it is necessary to use metal slips, as the wood would be liable, in washing and in the process of printing, to break away, or, at least, to warp. The block is previously dipped in a blanket-lined trough containing the color.

In hand block printing, the paper is dawn across a long table. The printer places his block accurately on the paper, the former being regulated by him at each corner with gauge pins, to insure accuracy at each length of printing. Then pressure, through an upright lever, is applied, and the impression made.

Blending is obtained by coating the blanket with a number of tints. An oblong trough, containing a number of varying colors, stands near the printer, and the attendant, with a long brush, dips it into the trough, and then brushes it over the blanket. Sometimes the blanket is merely dabbed over with several patches of color. The color is then transferred to the block, as previously described, the result giving blended and varying tints to different details of the design.

When the paper comes from the manufacturers it is of one uniform white tint, and requires the application of color grounds. The paper is carried through a machine on an endless roller, over a large cylinder, above which are fixed a succession of brushes, which are of different degrees of coarseness or fineness, as may be desired, to give varying textures. The paper comes in contact with an endless color-soaked blanket which supplies the color. After passing the brushes it travels over smaller rollers into the drying room, the length of its journey being regulated to complete its drying.

Flock paper hangings are printed in the details of the design in size. The flock—which is composed of the cuttings of woolen cloth, cut up in a mill to the necessary degree of fineness, and dyed—is then sprinkled over the paper adhering to the part charged with size. To get a higher surface the sizing and sprinkling are repeated.

Gold is applied much in the same manner, the metal dust being sprinkled on to the paper, and adhering to the forms previously printed in size. Gold leaf is sometimes used, and afterward drawn through a machine for burnishing.

Ordinary embossed papers are drawn through a machine into which is fixed a cylinder of brass on which is cut the necessary raised design. Other methods are used, the paper being prepared with gum size, parts are gilded, and then the paper is stamped with heated metal dies.

Embossed flock is the result of embossing on the top of ordinary flat flock.

The glittering grounds so much in vogue are produced by dusting on talc before the ground is perfectly dry, the gum contained in the color forming a size to which the talc adheres. These grounds, if used sparingly, give brilliant results. Fine effects are produced by printing in transparent colors on these grounds.

The most sumptuous wall papers are those in imitation of embossed leather. The best of these have all the artistic qualities of the latter material, the only difference being that the leather will wear longer, but in the paper there is nothing to complain of on this score. The production of these is an expensive process. If cost debars us from using the material in large quantities, it can be used for friezes, say above a high oak dado, or in squares or panels. The first process in manufacturing these is to have the design embossed on a copper sheet by a man possessed of the best artistic feeling obtainable; every valuable line and form of modeling by the artist will be afterward faithfully reproduced in the paper. From these embossed copper sheets an electrotype is taken, which forms the matrix into which the paper is pressed when in a moist state. Such a method results in far superior quality to impressions from roller plates. The surface is gilded with gold leaf or Dutch metal, and afterward entirely painted by hand. These English made papers are much more permanent than Japanese leather paper, and, I am sure, equal them in artistic qualities. Another treatment of these is to print with lacquers on a gold ground, obtaining the beauty of transparent tones of color.

There are many other forms of wall covering made of paper, such as Japanese leather papers, Lincrusta anagleptic, Tynecastle tapestry, etc., which I refrain from describing, as they would require an evening devoted to them entirely.

In addition to printed paper decorations, there is another and older method called stenciling, capable of many varied and delightful results. But cutting out in paper, zinc, or brass plates, ornamental forms, and laying them on a flat surface, rubbing through with short stumpy brushes charged with color—thus transferring the design to the object on which it is laid—any number of tints may be used, each requiring a separate stencil through which are cut the forms of each detail of each color. There are two general methods of stenciling, the first, which gives the actual design in the color applied; and the other, where the stencil is cut to form a background, so that the forms of the design are expressed by the original color of the ground. The latter, in cases where practicable, gives the purest and most brilliant result. I am not able to say whether the ancient Egyptians and Greeks used this method for the numerous repetitions of their conventional designs of the lotus and acanthus. Were we using such ornament now, this method would form the first stage, if they were afterward worked on by hand. However, the historical aspect of the subject is not in the present instance of importance. There is little doubt stenciling was largely used in the Middle Ages. In various parts of Italy and France I have seen the roofs of churches and the ceilings of palaces covered with charming examples of pure stenciling. It was very much in vogue during the last century and the beginning of this. In Indian temples it has been largely used. During the last century there were several guilds of stencilers, as it was an important form of industry. The Japanese have used it for the decoration of various materials, many of their silks and other dress materials being covered with ornament executed in this manner. Their skill in cutting the most delicate lines and forms has enabled them to execute the most wonderful and complicated schemes of color decoration on almost any substance. They cut the patterns in paper made of mulberry fiber, four or

five at a time, with a long thin knife and delicate punches. When finished, one sheet is covered with some adhesive material. On this is placed a number of threads of silk, which form ties to hold the whole design together. This process completed, another cut sheet is placed over the threads and underlying stencils and the whole pressed accurately together. I believe in many human hair is used instead of silk.

All the same effects as are found in wall papers may be achieved by stenciling. From the examples shown here of stenciling applied to wall papers by an advanced modern method, we find qualities much beyond what is usually accepted as stenciling. The process is not to be described any more than that of painting a fine water color, in which the artist uses numberless methods of his own to arrive at the expression of his idea. You may stencil bright ornament on a dead ground, or *vice versa*. The forms may be raised with repeated application of color, or stenciling may be executed on any specially prepared uneven textured ground. It may and is used largely for stenciling in the general color of any ornament on which you propose to relieve by shading or tinting, and is a very simple and direct method for accurate setting out, as it were, elaborate arrangements of ornament for such subsequent finish. In the decoration in ornamental forms of large interiors it forms the basis of all detail.

In cutting stencil plates, ties are necessary, in every detail, to hold the plates together. These, if judiciously distributed, form a great additional element to the beauty of the design, giving a fillip of light over the decorated surface. A practice to be condemned is what is termed the mending of ties. This method takes all the life out of the work.

In conjunction with wall papers, stenciling has many uses, such as the filling of forms where the set pattern of the paper will not apply, and is very effective in filling in special forms, such as the spandrels of arches, recesses, friezes, oddly inclosed and moulded spaces. Given such unusual shapes, opportunities occur for giving your whole scheme of decoration a fillip, additional interest, and unity.

In the wall papers now produced by many manufacturers we have, at a moderate cost, a means of using a very extended scale of the finest ornamental forms clothed in garments of an almost infinite number of color gradations, whether the schemes in detail are strong, broad or delicate. Those who possess any innate sense of good color, and a perception of the conditions of lighting and forms of rooms, may, in their homes, have their love of harmonies gratified.

Now that our education in decoration (as exemplified in wall papers) has been so much advanced during this last 20 years, instead of using narrow strips or borders about three inches wide, we crown our wall spaces with a frieze from 12 in. to 24 in. wide, thus having a fairly liberal decorative area. Such dimensions, I think, might be increased with advantage to 36 in. or 40 in. The frieze is now generally divided from the wall filling below by a moulded picture rail 2½ in. deep, making a pleasant and decided separation between the two.

These mouldings have a groove on the upper edge, into which small brass hooks are placed on which to hang pictures. It is both a useful and ornamental treatment, and obviates the use of brass rods, which are difficult to fix and soon tarnish.

I advocate the use of a deep 30 in. frieze for various reasons. In the first place, its generous area cuts to some degree the fetters of the designer. Here he may do his best, and when it is fixed we get the true and undisturbed value of his imagination. All the pictures being below his scheme of decoration, the moulding and frieze defeats that common practice of hanging pictures near the ceiling, and of building them up in pyramids on the wall under the vain delusion that they "match."

We quite forget that the treasures we hang on our walls are there for the delight of examination, and consequent revelation of whatever charm they may possess in themselves. By means of the picture rail and deep frieze we get nearly all our pictures on the line. This is the haven in which the artists who produce them would have them rest. The best position for all landscapes should be where their horizons are level with the eye. So also figures should have their eyes level with the spectator, if possible.

I have no sympathy with the common idea that you decrease the apparent height of your rooms by deep friezes. Supposing you do suffer from the optical delusion of losing 6 in. Is there not a sense of quaintness and comfort in a room that is low? At any rate we all feel how pleasant and cozy are the old farm houses with low timbered ceilings. This sense of snugness is well illustrated at the Chateau of Blois, where the timbered ceilings of the rooms are comparatively low, and are colored a sea green blue, to which is superadded an abundance of colored and stenciled ornament. There is a sense of restfulness and comfort in the two small ante-rooms (having ceilings of a similar character of decoration) which come between the two great halls or council chambers in the Ducal Palace in Venice. The vast pictures by Veronese and Tintoretti in the large halls are wonderful in themselves, but I venture to say they do not express the same quiet decorative fitness as do these small ante-rooms. The same may be said of the suite of small low-ceilinged rooms which were the favorite private apartments of Isabella d'Este in the Ducal Palace at Mantua.

This palace is by many considered the most magnificent example of interior decoration of the Renaissance. Yet these rooms and their decorations only live in one's memory out of the hundreds of magnificent apartments in this vast palace. I can well imagine the haven of rest they must have been to the daughter of the Ferraras, amid the turbulent magnificence of the Gonzagos. Of course, they have the added charm of low windows and vistas of the Lombard plains. In the Palazzo Rezzonico, now occupied by Mr. Browning, is a magnificent suite of reception rooms decorated by Tiepolo; attached to these is a suite of smaller rooms, delightfully quaint and low, showing that the old Venetians had combined with a love of magnificence a true appreciation of the pleasure to be found in a low and shadowed retreat. I by no means deprecate the fine sense of space and magnificence of rooms having large and generous dimensions, but we, who of necessity must live in apartments of small dimensions, should accept their proportions and devise our treatment accordingly, not cherishing the fallacy that good decoration consists of delusions of scale.

All papers used in staircases and other apartments where the light is defective should have their ornament bold and strong, delicate combinations of tones being reserved for rooms well lighted. There is a tradition that all ceilings should be light in scale. Well, many should be, but they may be successful in deeper and richer tones.

Remember the blue of a summer sky sometimes, and use it as a suggestion.

Gold on ordinary papers, when perfectly flat, is not always pleasant. The true glory of gold refuses to express itself except on undulating surfaces, where its metallic luster is developed.

In coloring the surrounding woodwork of rooms, it is a comparatively safe rule to select a tint from some section of the ornament in the wall paper. In selecting wall, frieze, and ceiling papers, it is well that the wall paper should be darkest in tone, the others ascending in the scale of light, and each having the same tints of color running through, but in varying degrees. This is recommended as avoiding an effect of disturbed harmony; but possessing a color instinct, daring arrangements of contrasts may be accomplished with success. I should say, avoid marbled wall papers, even if a Tadema is outside your means.

The great weakness of English coloring is its paucity. There is no reason why our wall papers should not be fuller and richer, containing more primaries and less dirty tones. The shadows made by projecting furniture and the absence of really brilliant light will always soften and give negative tones.

The old Venetians reveled in the fullness of tones; why should we not follow their example, and take suggestions from their source of inspiration, which was the barbaric splendor of Eastern color? We all recognize and admire the redundant richness of color as found in Persian fabrics, Japanese lacquers, and Moresque tiles. If this wealth and brilliancy is a delight in sunnier lands, it should be doubly welcome to us, where gray days are our portion, and the consequent need of the joys of color charm all the greater.

It is an error to think that on a ground of strong color our pictures suffer. If we take care that our areas of color are flat, and contain some sense of broad unity in the whole scheme, this will not occur. I mean in the absence of every disturbing or restless detail, such as we find in the elaborately printed efforts to reproduce naturalistic flowers, etc. I feel that these backgrounds may be as strong as you like, if the parts are well balanced, and each color of pretty near the same depth of tone. Gold or black picture frames are a sufficient separation. Besides, these being nearest the eye, are made up of mouldings, such modeled forms carrying the highest lights and the strongest darks, lift them clearly away from the merely surface color on which they hang. If you place any actual object on the most powerfully painted picture it will always tell as a strong disturbing element.

As the best French painters teach, the accessory, or object to be represented on the first plane, or nearest to the spectator, should carry the highest lights and the intensest darks. Strong lights may be used in the receding plains of the picture; but, to express their relative relations, the gradations of the shadows must be weaker in degree as distances are expressed.

This constructive method is, therefore, a question of values, so that the assertive expression of a moulded form cannot be much weakened by a backing of flat color. Black or gold, even if assertive, is always valuable in any color scheme. No one knows this better than the Easterns, as you will find these two elements playing an important part in all their compositions.

When gold is used it should be in liberal areas, not in thin strips, which is commonly known as "hatching." A common cry now is, that what is termed an "all over" treatment is best; that is, the areas of the details of the design should be nearly all equal, so that no feature should obtrude itself in the design. I am not altogether in sympathy with this variation in areas; the treatment may be rendered quiet in effect by a nearer relationship of tones in the coloring. If certain strong elements in the design assert themselves, in horizontal and perpendicular lines, why quarrel with such results? as nearly all fine expression in architecture is obtained by the accentuation of horizontal or vertical lines; triangular assertions of features are certainly objectionable.

I have every reverence for the great designs of the past and its suggestions, and there are certain dignified uniting lines and forms that we may well borrow from the Renaissance, or other periods of ornament, which are invaluable in the expression of vertical or horizontal forms necessary to fill certain decorative spaces, but underlying or woven into such valuable accentuating forms of expression there should be added something of the designer's own individuality or creation. I am sorry to see so much borrowed from the period of the decline of fine styles.

It is lamentable to see the present craze for the slavish copying of French rococo ornament, a period containing all the worst features of an expiring art. How these can be accepted in preference to the fine English feeling for design and color, exemplified in the productions of our manufacturers during the last fifteen or twenty years, is a mystery to me. The French papers at the exhibition of 1889 may have created this fashion. If such is the case, the influence has been on the wrong side, from I am sure the wealth of color, original and artistic design of the English exhibits of this material completely threw in the shade the worn-out features of French design. Their patterns gave evidence of archæology dressed in smart new clothes only, not of any new thought.

Two of the most important qualities in decorative design for wall papers should, I take it, be a general flatness and color harmony.

By the former I mean the spaces of color forming the scheme should be flat in themselves. If any attempt is made at relief, it should be of a rigid or conventional character, in the form of precise lines, or melting gradations, following and accentuating the leaves and other forms, etc. Flowers modeled with endless printings defeat the repose and breadth of wall paper as a decorative accessory. How can we hope to give the adequate subtlety of the numberless gradations of flowers by machine printing and the crudeness of distemper color when the best of the Dutch flower painters fail, with all their delicate manipulation, endless labor, and the wider range of possibilities of the mediums of oil or pure water color, in rendering perfectly the numberless subtile tones of flowers?

The aim of wall paper decorations is not realism.

If flowers and foliage are the source from which our creation springs, we should try to give an idealization of their charms, coupled with a subtile and critical selection of those parts that assume the finest curves, and give the most interesting areas of color. This idealization must be expressed by what I may term convention, or a fine sense of adaptation and ordered arrangement to its decorative purpose.

We venture on a thorny path when we talk of the artistic treatment of wall papers. Any theories that I may have propounded are only those of an individual. Gather lessons in decorative color from the broad unity and tender harmonies of twilight, rather than the restless brilliancy of noon.

We are now so stored with knowledge of every period and style of decoration that the expression of any personal views or attempts at creation is like venturing on thin ice.

We hear from one that the archaic work of the Greeks is greater than its perfect fulfillment in the age of Phidias; from another that the art of the mediæval ages embraced all that was living and fervid. Raffaelle and Michael Angelo are torn from their thrones to make room for Carpaccio, Bellini, and Bottocelli. Rembrandt gives way to Velasquez. Preraphaelism is asserted to be a dead letter, and the new and brilliant planet, dubbed impressionism, to contain the cream and embodiment of all art, and so on and so on.

I make no apologies for quoting the great painters of the past as bearing on ornament. I maintain that mere ornamentalists have not given us better decorative forms (exclusive of figures) than the former.

The searching nature of a painter's practice goes deeper into the mysteries of color in relation to nature, and when he adds ornament to his work, it is, I take it, more subtile than that of the man whose aim is on a lower scale.

I fail to find ornament containing more color, harmonies, and invention than that found in the works of Francesca, Carlo Cravelli, Mantegna, and Holbein.

It seems to me the invention, beauty, and variety of ornament as displayed in Mantegna's frescoes in the church of the Erimatana, at Padua, the castle of Mantua, and the church of S. Zeno, in Verona, has never been excelled by men whose sole function is the making of ornamental design. The strength, vigor, redundance of color, and decorative fitness, displayed by him in the use of apples, lemons, pomegranates, olive and laurel leaves, etc. (which are so essentially decorative in themselves, quite independent of archæological detail), show a veritable triumph from a decorator's point of view.

We may endeavor to unweave the web of fashions and infatuations for distinct periods, and clearly find that in all of them great truths and precious jewels of beauty were perpetuated. There is one advantage in these fashions, namely, that the close research into each period of each man's work reveals a special charm of its own. They tell the ordered story of the revelations that were vouchsafed to themselves. The horizons of their accomplishments should not, however, enfold ours; from them we may gather guidance and suggestions only, which shall increase the clearness of our mental visions in endeavors to evolve newer forms of beauty from the treasure house of nature. Let not our accumulation of knowledge forge fetters, to dull or stifle the creative qualities with which we may be dowered. Remember that design is not adaptation only.

When we have readapted, placed here, placed there, turned round and twisted in numberless ways the details of other periods, until the hackneyed forms become a weariness rather than a pleasure among our household gods, we may awake to the conviction that there is in the garments of the earth an inexhaustible mine of lovely color and forms crying out for translation.

Why not, metaphorically, sail with the bees down the summer winds, and sip the honey of suggestions (so fraught with the seeds of creation) from a thousand flowers, from the sinuous anatomy of trees and plants, the plumage of birds, the color harmonies of shells and autumn leaves, of moss and lichen, and the countless details of nature? If your worship of her is sincere, then will follow the clearness of vision to grasp her revelations.

ST. THEODORE, VENICE.

THE Venice correspondent of the *Scotsman* writes: In 1127 three giant granite monoliths, each about 50 feet in height, were brought to Venice from the East. They were bought and paid for, and not stolen, as everybody says. One lies buried in the lagoon in front of the Doge's Palace and the other two were set up in 1173, and these are they that now so majestically grace the entrance to the city from the Piazzetta of San Marco. In or about 1200 the two patron saints of Venice were set upon their summits—St. Theodore standing on a crocodile on the one and St. Mark under the symbol of a noble lion on the other.

For nearly seven centuries they have stood on their noble pedestals keeping watch and ward over the Queen of the Adriatic at their feet. But in these recent days both saints and pedestals showed signs of decay, and it was feared if nothing were done Venice might wake up one day to find that her long-neglected saints had become her destroyers. Accordingly, the Great Lion of St. Mark and its pedestal were first examined and repaired. Then St. Theodore and his crocodile and his pedestal was subjected to the same scrutiny and kind treatment, and I purpose telling in few words the story of that, with the strange discoveries it has led to.

First, St. Theodore and his crocodile were brought down to the ground. He was found to stand 10 feet in height, and his animal measured 14 feet in length. Both were made of Greek marble, bound together with iron coated with bronze. As only in Athens iron was so coated, a Greek origin was suggested. On closer examination it was found that half the marble was good and half was bad. Then it was discovered that half the workmanship was good and half bad. The

head and upper part were of good material and well carved; the lower half of the body, like that of Nebuchadnezzar's image, is base in material, and besides it is base in execution. Then it was discovered it was not St. Theodore at all, nor one homogeneous person even. The figure has the head and bust of a Roman emperor, with the lower part of the body and limbs of some inferior person. But the legs of the figure and the part of the body of the crocodile on which it stands are one piece of marble, and a closer examination of the animal showed that its form was as much that of a dragon as a crocodile.

A good deal of discussion has been carried on concerning these matters. The opinion that is gaining ground is that of Sig. Vendrasco, who is the clever engineer in charge of these monuments, that the upper part of the figure is that of the Emperor Constantine, with his crown of laurel and breastplate with the Christian cross on it and decorated with eagles and lions, and that the lower part is that of an inferior Greek statue. A curious fact is that the shield is on the right arm, while the left hand holds the spear. The spear is wood coated with bronze. What is certain is that it was set up to represent St. Theodore and his crocodile, which is the main thing. Now for what has been done. The statue was originally in seven parts; it was broken into 100. The abacus of the column was shattered. The capital was not a solid block of marble, but a hollow cylinder filled with bricks and rubbish, and the rain entering and the frost affecting it, it was split vertically and horizontally. The huge monolith, weighing with capital, base and statue over 100 tons, leaned, like Pisa's tower, a long way off the perpendicular.

Signor Vendrasco has straightened the column, which, unlike its sister companion, goes into a socket over a foot in depth. He has bound up with copper girders the capital, repaired and relaid the abacus, and he has made a new man of St. Theodore and set him up once more on his crocodile's back on his lofty pedestal. He has made a lighter man of him, for he has taken out of him over 2,000 lb. of lead and 300 of iron and 150 of copper. The work was only completed the other day, but it is hoped no time will be lost in removing the unsightly scaffolding, so that Venetians may once more be able to see their saints, and visitors, who are now pouring into Venice, may be able to see in all their symmetry and beauty these ancient historic monuments. As in the case of the Great Lion here, casts of St. Theodore and his crocodile have been taken, which will be sent to Rome, Paris, London, and New York in all probability.

GLEANINGS FROM THE GERMAN JOURNALS.

By FRANK X. MOERK, Ph.G.

Adulterated Litharge, containing ten per cent. of matter insoluble in acetic acid, is reported by Dr. A. Schneegans; the adulterant was proved to be fine white sand colored with a little ferric oxide.—*Journ. Phar. Els.-Lothr.*, 1893, 41.

Santonin Reactions.—1. The color reaction with sulphuric acid and solution of ferric chloride, if applied as follows, will uniformly give the same result: In a test tube, dissolve the santonin in sulphuric acid, in another tube mix about one-half drop of solution of ferric chloride with one c. c. water; upon mixing the two solutions, considerable heat is evolved, but only enough to cause a yellow color in the mixture; if the test be warmed for a few seconds by use of a spirit lamp or Bunsen burner, a fine violet coloration appears.—Stadelmann, *Sudd. Apoth. Ztg.*, 1893, 70.

2. If santonin be heated with potassium cyanide until a fused mass results, a red color appears, changing quickly to brown yellow; the mass dissolved in water or solution of potassa forms a brown solution showing marked green fluorescence.

3. In fusing santonin with potassium hydrate a red coloration is noticeable, becoming darker by prolonged heating; the aqueous solution of the fusion is red, but changes through brown yellow to yellow.—J. Schermer (*Nederl. Tijdschr. v. Pharm.*) *Apotheker Ztg.*, 1893, 77.

Theobromine Estimation in Cacao Beans.—The beans with an equal weight of purified sand are finely comminuted and then six grammes of the mixture extracted with petroleum ether in a continuous extraction apparatus for ten hours, to remove the fat; the residue is boiled for one-half hour with 200 c. c. distilled water and 6 grammes freshly prepared pure lead hydrate, strained, expressed, and filtered; the insoluble portion is twice boiled with 100 c. c. distilled water and the united filtrates evaporated to 10 c. c., transferred to a separating funnel and agitated for three minutes with 100 c. c. chloroform. After complete separation of the chloroform, requiring about three hours, the chloroform is removed and the operation repeated three times. From the combined chloroform solutions the greater portion of the solvent is distilled off, the remaining solution transferred to a tared beaker, the flask rinsed with warm chloroform and the contents of the beaker evaporated to dryness in a water bath. The theobromine is obtained in the form of almost perfectly white, micro-crystalline powder which, by ignition upon platinum foil, leaves only traces of ash.—P. Suss (*Ztschr. f. anal. Chem.*), *Apotheker Ztg.*, 1893, 78.

Lanain, patented as a pure neutral wool fat, is put upon the market as a soft, yellowish, homogeneous mass, melting at about 36° C.; it has only a faint odor indicative of its origin and loses this after some time; applied to the skin, this odor is not persistent; it is perfectly neutral in reaction and permanent in air. By mixing with water it changes to a white, smeary ointment, the surface of which becomes brown on exposure; it is possible to incorporate as much as four times its own weight of water; by incorporating 25 per cent. of water, lanolin is obtainable. Lanain is very quickly absorbed by the skin, so that this property, also possessed by lanolin, is not due to the water contained in the latter. Lanain is offered as a substitute for the different fats and some fixed oils in the preparation of ointments, pomades, etc.—Dr. H. Hirzel, *Apotheker Ztg.*, 1893, 57.

Permanent Physostigmine Solutions can be made by dissolving physostigmine in carbonated water, transferring to small tubes, heating to 100° C. (which expels the excess of carbonic dioxide and sterilizes the solution) and hermetically sealing the tubes. The decomposition, according to Sabbatani, is due to the alkalinity of the solution caused by the solution taking up alkali from the glass and becoming red; the presence of the weakest acid, however, prevents this decomposition.—(*Riforma med.*) *Rundschau*, 1893, 144.

Distinction between Soluble and Organized Ferments.—The addition of one per cent. of sodium fluoride immediately and permanently arrests the fermentations caused by organized ferments without interfering with the fermentations produced by soluble ferments. M. Arthus and A. Huber, in examining the action of sodium fluoride upon different fermentations, found that the process of decay, the ammoniacal fermentation of the urine and the alcoholic fermentation of sugar were prevented by the above chemical, while the action of saliva, invertin, emulsin, pepsin, and pancreatin were not interfered with. In the study of unknown fermentations, the use of sodium fluoride will give important information in deciding the cause of the fermentation. (*Arch. d. Physiol.*) *Pharm. Centralhalle*, 1893, 70.

Test for Pilocarpine.—The hydrochlorate of this alkaloid, mixed with calomel, becomes black, if exposed to moist air, or if it be breathed upon. The same reaction is given by cocaine hydrochlorate (*Am. Jour. Pharm.*, 1891, 132), although the color is not so intense.—W. Lenz, *Pharm. Centralhalle*, 1893, 79.

Teucrin is the name given by Professor Von Mosetig-Moorhof to an extract of the plant *Teucrium Scordium*, found throughout central Germany, and which has been known since the earliest times as an excitant and anti-ferment. The remedy is prepared by making a decoction of the dried plant, concentrating to honey consistency and purifying by addition of alcohol; the filtered solution is evaporated until a specific gravity of 1·15 is obtained, when the extract is sterilized and hermetically sealed in glass vials holding three grammes. In appearance it is a dark brown liquid, having a characteristic odor; it is acid in reaction, ten grammes requiring 11·4 c. c. $\frac{n}{10}$ alkali for neutralization; total solids 20·80 per cent., including 4·60 per cent. ash. Other species of Teucrium, also Pulegium vulgare, possess the same medicinal virtue, but in a lesser degree. Teucrin has been found a valuable remedy in the treatment of the fungoid local diseases, abscesses; it is used hypodermically and acts by causing increased blood circulation in the diseased part.—(*Wiener. Med. Bl.*) *Pharm. Centralhalle*, 1893, 89.

Pepsin.—At a recent meeting of the Berlin Pharmaceutical Society, Dr. F. Witte, speaking upon pepsin, stated that too stringent requirements regarding perfect solubility of pepsin were being made; that from his experience pepsins forming perfectly clear solutions had decreased albumen-dissolving power. Pepsin dissolving 4,000 parts albumen could easily be made; he had been manufacturing, for American export, pepsin dissolving 10,000 parts of albumen, for some time. At the Columbian Exposition he intended to exhibit an *absolute pepsin*, but declined to state anything regarding its albumen solvent power.—*Pharm. Centralhalle*, 1893, 92.

Caffeine-iodol.—If caffeine and iodol, in molecular proportion, be mixed in alcohol solution, a crystalline addition product separates. The product is of a light gray color, odorless, tasteless, and insoluble, or nearly so, in most solvents; it contains 74·6 per cent. iodol and 25·4 per cent. caffeine. As iodol, by prolonged keeping, liberates iodine and thus has injurious effect, the above permanent compound is considered worthy of trial.—E. Konteschweller, *Pharm. Centralhalle*, 1893, 95. *Amer. Jour. of Pharmacy.*

THE SPECIFIC HEAT OF LIQUID AMMONIA.

By C. LUDEKING and J. E. STARR.

THE specific heat of liquid ammonia, though it has often been the subject of calculation in development of theory and practice, has not yet been satisfactorily determined experimentally, if we except the work of Regnault. His results, however, were unfortunately lost during the Paris Commune. He assumed the specific heat to be 0·799. Since then the interest in this constant has very considerably increased, through the rapid development of the artificial ice industry. Generally the specific heat has been taken at unity. Thus De Volson Wood in his "Thermodynamics," page 337, recommends this value "until the experimental value is determined."

It was our good fortune to have ready access to all the means necessary for executing the somewhat laborious experiments involved, and we take this opportunity to present briefly the results of our work. The liquid ammonia used in the experiments was found on examination to contain 0·3 per cent. of moisture and on spontaneous evaporation to leave only a trace of residue. The impurities were therefore of no consequence in influencing the result to the limit of accuracy intended.

Of this liquid ammonia 10·01 grams were introduced into a small steel cylinder of 16·122 c.c. capacity, stoppered by a steel screw. The mode of filling was quite simple. After cooling the cylinder in a bath of the liquid ammonia itself and while still immersed it was possible to pour it brimful by means of a beaker. The steel screw stopper, also previously cooled, was then inserted and drawn almost tight. On then removing the cylinder from the cooling bath the liquid contents gradually expanded and escaped in quantity proportional thereto, and besides a very small vapor space was allowed to form as is indicated in the experimental data. Then the stopper was driven tight. Thus the error in the result, due to the latent heat of condensation of vapor of ammonia in the course of the experiments, was reduced to a minimum and rendered, as will be seen, almost inappreciable in its influence.

The cylinder was perfectly free from leakage and remained constant in weight during each series of determinations. It was suspended in the drum of a Regnault apparatus heated by the vapor of carbon disulphide. The entire mode of procedure was in all details that commonly used in the Regnault method. After the cylinder had been heated for about six hours it was dropped into a brass calorimeter whose water value was 1·36 cal. and which contained 150 grams of water. In each experiment it required very nearly two minutes to raise the calorimeter to its maximum temperature. The influence of loss by radiation was reduced to a minimum by the Rumford manipulation. The thermometers used were standardized, carefully compared and read to hundredths of a degree by means of a magnifying lens. The experiments were conducted sufficiently far from the critical temperature, which, according to Vincent and Chappuis, is 131° C.

The following are the data of Experiment I.:

Weight of steel cylinder and ammonia	81·008	grams.
Weight of steel cylinder	70·998	"
Weight of ammonia	10·01	"

The specific gravity of liquid ammonia being 0·656, the volume of 10·01 grams is 15·26 c. c.

Total water value of calorimeter, thermometer and water	151·76	cal.
Water value of steel cylinder	8·34	cal.
Temperature of air	25·4°	C.
Temperature of steel cylinder	46·51°	C.
Temperature of calorimeter after immersion	26·69°	C.
Calorimeter before immersion	24·44°	C.
Rise in temperature	2·25°	C.

Thus 341·46 cal. were given off by the cylinder in cooling 19·82° or 17·23 cal. for one degree. Of this 8·34 cal. are due to the steel cylinder itself, leaving 8·89 cal. for 10·01 grams of liquid ammonia or 0·888 per gram = specific heat. In a second and third experiment the values 0·897 and 0·896 were obtained. The determination of the specific heat of liquid ammonia would be influenced, as stated, by the latent heat of condensation of part of the small quantity of vapor present, when the cylinder cools in the calorimeter. This would to a degree be neutralized by the contraction of the liquid ammonia itself in the cooling and the consequent formation of more vapor space.

It seemed desirable to ascertain the influence of these factors collectively by experiment. For this purpose specific heat determinations were made in a way somewhat different from the ordinary. The steel cylinder was cooled in an iron shell in melting ice, instead of being heated, and then introduced into the warm calorimeter water. The mode of procedure was in detail similar to that described above, and we will therefore only give our results. In three experiments the values 0·878, 0·863, and 0·892 were obtained. They are a trifle lower in their average than the results obtained by the ordinary method. It is reasonable to assume that they are somewhat low, while, as stated, the other results are presumably somewhat high, and, in order to arrive at the specific heat of this substance nearest the true value from our experimental evidence, we will take the average of our six values, viz.:

0·888	1st series.	0·878	2d series.
0·897		0·863	
0·896		0·892	

and state it as being = 0·8857.

We beg herewith to acknowledge our obligations to Chancellor W. S. Chaplin and Prof. Wm. B. Potter for kindly placing the laboratories under their charge at our disposal.—*Amer. Jour.*

IMPROVEMENTS IN THE MANUFACTURE OF BORAX.

By H. N. WARREN.

BORACIC or boric acid, as is well known, is one of the feeblest acids to be met with, being readily replaced by all other known acids, and even in some respects by carbonic acid; but on the other hand, viewing it as an anhydride, we find it standing foremost, and at elevated temperatures even slowly replacing such acids as phosphoric and sulphuric acids. Boric anhydride is in fact when pure almost entirely fixed at the most elevated temperatures obtainable. A tared platinum crucible containing an ounce of the substance, which had been exposed to a full white heat for over two hours, was found after reweighing to have lost in weight but five grains. The peculiar properties of the acid, however, are vastly different; volatilizing readily upon the application of heat, in so much that it is practically impossible to distill a solution containing boracic acid without a portion passing into the distillate. Again, if boracic acid is melted at a low red heat in a platinum or other suitable vessel, as long as aqueous vapors are discharged, volatilization of the boron present is perceptible until about 70 per cent. of the water present is discharged, the remaining portion of water being expelled in an almost pure condition, the action meanwhile gradually subsiding, leaving the anhydride.

Taking advantage of these properties, the author has devised a method by which the production of borax is brought about, by subjecting common salt (sodium chloride) to the action of the crude boracic acid of commerce, aided by superheated steam; the decomposition is effected by using large clay retorts, composed for the most part of acid-resisting material, the tops being tubulated to allow the introduction of the steam required during the reaction. The retorts are charged with an intimate mixture, consisting of well-ground salt and boracic acid, the neck of the retort being connected with a refrigerator for the purpose of condensing the acid thus obtained. Directly the retorts assume a low red heat, hydrochloric acid is disengaged in abundance; the heat is now slightly raised, and the supply of steam so regulated that water in the form of steam is allowed to enter through the tubulure in sufficient quantity to condense the hydrochloric acid formed in connection with the refrigerator. The result is speedy and complete decomposition of the salt employed, with the production of anhydrous borax, which remains in the retorts, while a dense and pure acid collects from the condenser. When the action is terminated the content of the retorts, consisting of anhydrous borax, is ejected while still red hot into cold water, where it is allowed to remain for 48 hours, during which time it will have passed into solution, from which, by the ordinary routine of crystallization, it is obtained as ordinary commercial borax.—*Chemical Trade Journal.*

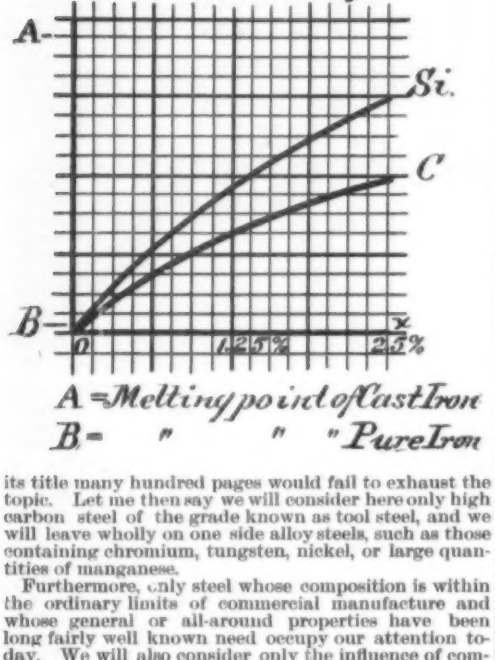
SIBLEY COLLEGE LECTURES.—1892-93.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

ON SOME OF THE MECHANICAL PROPERTIES OF HIGH STEEL AS RELATED TO ITS COMPOSITION AND STRUCTURE.*

By JOHN W. LANGLEY, Ph.D.

THE subject of steel is so large a one it will be necessary in the outset to lay down the limits of the present lecture, because even when restricted to the scope of



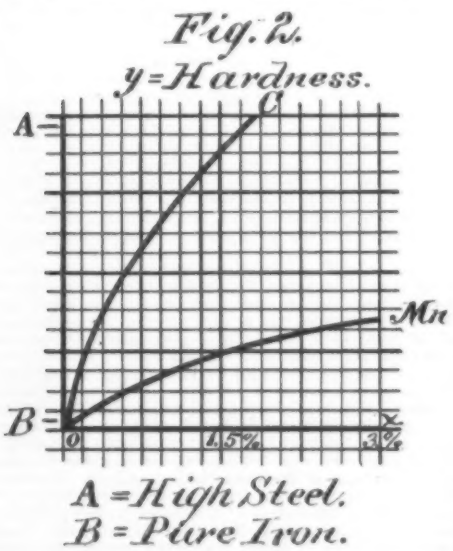
its title many hundred pages would fail to exhaust the topic. Let me then say we will consider here only high carbon steel of the grade known as tool steel, and we will leave wholly on one side alloy steels, such as those containing chromium, tungsten, nickel, or large quantities of manganese.

Furthermore, only steel whose composition is within the ordinary limits of commercial manufacture and whose general or all-around properties have been long fairly well known need occupy our attention to-day. We will also consider only the influence of composition on its properties in their general or average action rather than in any special case.

First, then, I will offer you a definition of steel which may serve for the purpose of this lecture, premising, however, that I do not offer it as a universal formula, or one which is not open to adverse criticism. Steel may be defined as "iron holding in solution (or combination) carbon principally, and also small quantities of silicon, phosphorus, sulphur, and manganese."

The word solution in the above definition dominates the whole expression; let me explain the sense in which it is used. When a student begins the study of chemistry he soon learns that chemical combinations occur in definite and fixed proportions based on atomic weights. Sodium chloride, for example, is a perfectly definite atomic combination, unchangeable, we believe, in its percentage composition without complete loss of its identity. It may stand as the type of all this class of substances. But also we know of a different kind of union between bodies, called solution, as when sugar or salt dissolves in water; here both the solids and the water undergo a progressive modification of properties with change of the relative proportions of the two in the mixture.

This is a type of indefinite composition. But many phenomena known to-day point to a gradual merging of these two classes into each other. Some chemists



consider all solutions as forms of atomic combination. Experiment and theory unite to show that the mere act of dissolving a body, as sodium chloride, in water tends to dissociate it into its elements, and if a sufficient volume of water is taken, an actual liberation of chlorine seems to occur. I consider that the kind of union between carbon and iron exhibited by steel is on the border line between a typical chemical compound and a simple aqueous solution, but nearer to the latter than to the former.

* A lecture delivered before Sibley College, Cornell University, December 8, 1892.

All tool steel contains in addition to iron and carbon four other elements—silicon, sulphur, phosphorus, and manganese. The first three are unavoidably present, and the manufacturer tries to have their proportions as small as possible; the last one is intentionally added because of its beneficial effect on steel during hot working. It is doubtful if manganese exerts any good influence on cold steel, and it is certain that if its amount is not very small its action is pernicious.

The ranges of composition of tool steel are as follows:

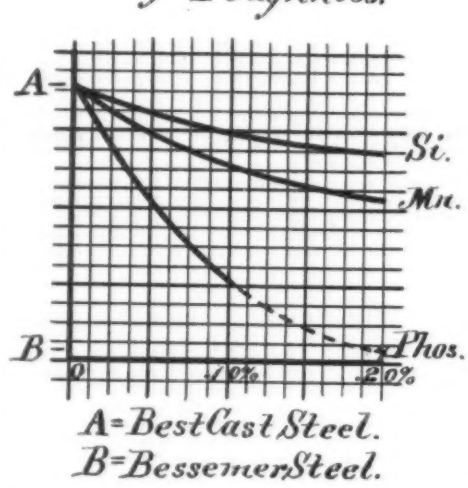
	Ranges.	Average High Grade.
C.	0·5 —1·50	1·20
Si.	0·05 —0·30	0·20
P.	0·01 —0·05	0·02
S.	0·003—0·04	0·008
Mn.	0·08 —0·50	0·20

The action of foreign matter on iron when melted with it is governed by the following general law:

"Each addition of small quantities of any of the above elements to iron reduces the melting point, the ductility, and the electric conductivity of the iron, while at the same time it increases the hardness and the magnetic retentivity."

But the individual effect of each of the five elements, carbon, silicon, phosphorus, sulphur and manganese, differs greatly on the general mechanical properties. If we plot this graphically, we find that none of them can be expressed as a linear function of the equation of a curve. By this I mean, letting y equal any property of steel which can be expressed on a numerical scale, and x the corresponding quantities of the element, then in a diagram constructed on rectangular axes we shall not get a straight line, but instead, curves having a general resemblance to the parabola, $y^2 = px$, but not accurately so. We may write them approximately $y^n = fx$, where f itself may become variable. They all tend, with possibly the exception of the manganese hardness curve, to become asymptotes to the axis of x.

Taking up for consideration the specific action of certain elements, we notice that the one which has the most notable influence on the melting point is silicon, and next carbon. In Fig. 1 the vertical axis is drawn with reference to A and B, while the horizontal axis represents per cents. of silicon and carbon, both of these being in the so-called combined state, *i. e.*, held perfectly in solution.



The lowered melting point of steel is the principal reason why it is practically impossible to weld it. The metal passes through a granular stage before complete plasticity is reached, and then almost at once melting begins. The plastic state, which extends over a considerable temperature range in iron and very mild steel, is so brief in high steel that only rods of very small section can be heated with sufficient uniformity to permit of welding during the brief period while the metal is cooling through this plastic state. Very small tool steel rods of less than one-quarter inch cross section can be welded fairly well, but not large ones from this cause. Silicon is especially prejudicial in this respect.

The element which confers hardness on steel is chiefly carbon. It is pre-eminent in this respect, but manganese can nearly rival it, provided it is introduced in very considerable quantities of from seven to twenty per cent. This is shown in Fig. 2. Here small quantities of manganese are inferior to carbon in hardening power, but when manganese reaches fifteen per cent. it rivals carbon at one per cent.

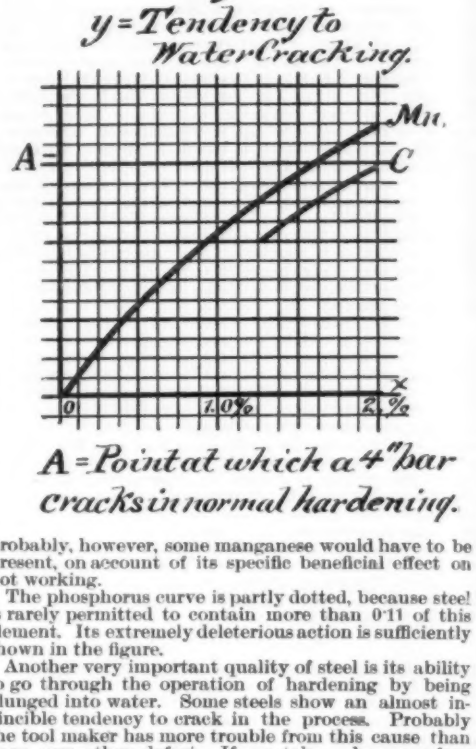
The most useful tool steel is that which combines toughness with hardness. Mere hardness can be readily attained, as for instance in chilled cast iron, or in steel holding a large quantity of both carbon and manganese; but in these cases the material will be very brittle. A tool which will hold an edge when working on fairly hard material or when cutting at high linear velocity must possess enough elasticity and ductility to enable it to yield slightly under the fluctuating stresses brought to bear on it by the work. The best steel after hardening and tempering will do this. Therefore, the best steel for a cutting tool for working either wood or iron is the one which combines toughness with hardness. If we bring various samples of steel as nearly as possible to the same degree of hardness, then they will be found to differ greatly in their toughness, *i. e.*, to forces tending to crumble away the cutting edge.

In Fig. 3, uniform hardness is assumed. y is the axis of toughness. The point, A, represents the best grade of steel made from Swedish iron. B, a cheap grade of Bessemer steel.

A and B have the following composition:

	A	B
Silicon	0·12	0·10
Manganese	0·15	0·80
Sulphur	0·004	0·04
Phosphorus	0·01	0·11
Carbon	1·25	1·25

The curves in this figure are concave upward because they indicate decreasing values of y. Also they cut the axis of y at a point above A to indicate that the ideal steel would consist only of iron and carbon;



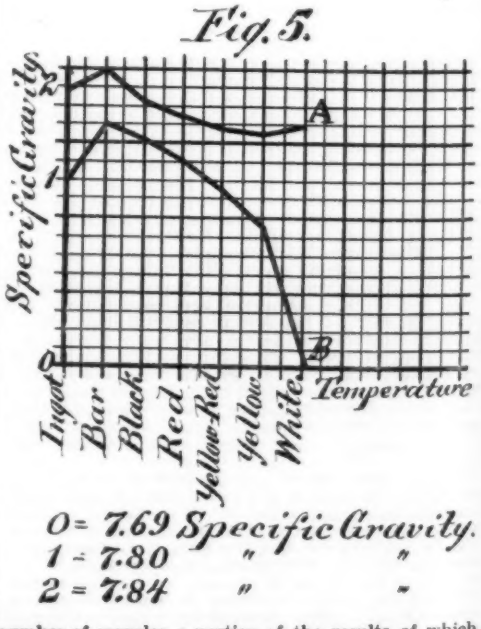
probably, however, some manganese would have to be present, on account of its specific beneficial effect on hot working.

The phosphorus curve is partly dotted, because steel is rarely permitted to contain more than 0·11 of this element. Its extremely deleterious action is sufficiently shown in the figure.

Another very important quality of steel is its ability to go through the operation of hardening by being plunged into water. Some steels show an almost invincible tendency to crack in the process. Probably the tool maker has more trouble from this cause than from any other defect. If we take a bar, say four inches in diameter, and harden it, using all normal precautions, then it will be found that some steels will inevitably crack. Let this state, where the four inch bar will crack even in the hands of an expert, be called A in the annexed diagram, Fig. 4, then if we start with carbon at 1·25 as a minimum, we shall find manganese to be the agent which chiefly causes water cracking, and it is this evil tendency which compels the manufacturer to keep this element low in amount, much less in fact than he would like to use to make the metal go readily through the rolls without breaking.

The cause of water cracking is partly chemical, partly mechanical. Chemical, because of the changed condition of the carbon brought about by sudden cooling; mechanical, because this results in a violent expansion of the metal; hardened steel being of an increased volume and a lessened specific gravity compared to the same piece before hardening.

Some years ago the writer made a study of a large



number of samples, a portion of the results of which are given in Diagram 5.

By means of a crown drill samples were bored out from a set of ingots containing different percentages of carbon, but which were alike in other respects. These are marked "ingot" in the figure. The ingots were drawn down into ⅞ inch round bars, which were then heated to a dazzling white heat at one end, while they were left cold at the other. In this state they were plunged into water, and when cold broken off into short pieces which represented the temperatures noted in the figure. This method of studying the

effect of heat on fractures was devised by Mr. William Metcalf. On taking the specific gravities of these samples it was at once apparent that the rods in the original state were all denser than the ingots, but from this point on the pieces decrease in density in proportion to the temperature to which they had been subjected, showing a permanent expansion by the operation of hardening. Also, the higher the carbon the greater was the disposition to crack in the overheated samples.

In Fig. 5 only two sets are shown.

A had carbon, 0·526
B " " 1·080

The actual figures from which the curves were plotted are:

	A	B
Carbon	0·529	1·080
	Densities.	Densities.
Ingot	7·841	7·805
Bar	7·844	7·825
Black	7·831	7·811
Red	7·826	7·798
Red-yellow	7·823	7·769
Yellow	7·814	7·741
White	7·818	7·690

Sample B was cracked in the pieces heated to a white and to a yellow heat. Sample A was not cracked in any of the pieces. As a red-yellow heat is the best temperature for hardening, it is at once apparent from the above figures why high carbon makes this operation so critical a one. Also, why steel should never be heated above the minimum temperature necessary to thoroughly harden it.

A few words may be added here on shop precautions in the hardening of steel which do not depend on its chemical composition.

It takes much longer to heat a piece of metal uniformly than is generally supposed. I found that on placing a piece of steel ¾ of an inch in diameter by 3 inches long in the interior of a red hot iron tube, it took about 20 minutes for it to attain sensibly the temperature of the surrounding walls.

All pieces showing sharp projecting angles, such as milling cutters and large twist drills, are especially liable to crack, because of uneven heating, since the tendency is for the outside to be much hotter than the interior. Such pieces should be very gradually heated in a moderate fire burning without flame; they should be frequently removed for short intervals and finally heated a little above the best temperature for dipping. Then they should be suffered to cool very gradually to the critical temperature and be plunged into water.

The reason of this is because during the heating the outside tends to be the hottest, while during cooling the reverse is the case; hence by slightly overheating and then catching the right temperature during the cooling stage a more uniform distribution of heat between the outside and interior will result.

CONFETTI AND SERPENTINES.

WHO is there in Paris that is not acquainted with "confetti" (those of paper, of course), on account of having received them square in the face, or of having thrown them at the merry promenaders who, on public holidays, give the streets a picturesque and sometimes so animated an aspect. This year they have had a particular success during the days of Mid-Lent and Shrove Tuesday.

At Nice, Barcelona, and Venice, in the warm and charming countries in which King Carnival sees the return of these customary splendors every winter, the confetti, as well known, are bonbons of plaster, of which the weight is sufficient to permit the promenaders to answer the flower bedecked and garlanded balconies. The merry combatants protect their faces with netting or metallic masks, and, although the plaster breaks and spots the parti-colored costumes with white, the incoherence is only the greater for it, and the gayety increases so much the more.

FIG. 1.—A VENDER OF CONFETTI.

At Paris the mask is impossible for the promenader who strolls along the boulevards as a simple onlooker. His tranquil humor will doubtless easily put up with a handful of small pieces of paper that lash his face, but it may be presumed that he would not, without protest, accept a hail of small pieces of plaster from which his clothes would have much to suffer.

So the confetti of paper, the only kind possible at Paris, has acquired the freedom of the city among us, and the street venders, who on certain days of merry making go about hawking this article at always lower prices, can still hope for nice little profits.

These confetti, in fact, the net cost of which is insignificant, are especially profitable to the middlemen. And, in reflecting upon it, it seems very just that the money that the Parisian thus throws into the street, voluntarily and for his pleasure, should go to give a little comfort and gayety, moreover, to those who, far from knowing the superfluous, have not always the necessary.

The manufacture of paper confetti is exceedingly simple. The crude material is the colored paper used for show bills, and certain manufacturers employ as many as fifteen different colors. The sheets are superposed to a thickness of 3 or 4 inches, and the package thus formed is slid between two steel tables provided with numerous apertures from 2 to 3 inches in diameter. These apertures are opposite each other in the two tables.

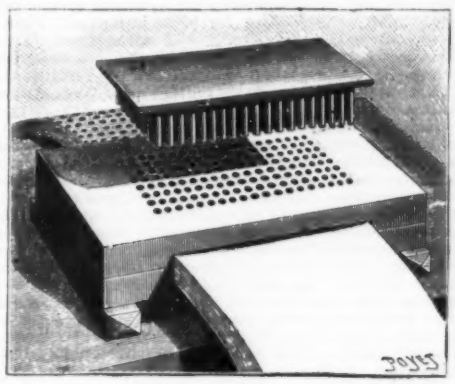


FIG. 3.—APPARATUS FOR THE MANUFACTURE OF CONFETTI.

Steel punches, formed of an equal number of solid cylinders suspended from one plate in common enter, by friction, the corresponding apertures of the double table, Fig. 3. These punches come into contact with the material to be perforated, and, ever pushed forward by the great pressure exerted upon them, remove throughout the whole thickness of the paper a series of disks that fall into a basket placed beneath. The punches are withdrawn mechanically, the paper is shifted in the same manner, and the operation, which has lasted a second, begins anew. As may be seen, these confetti are not cut out, but stamped out; and in this there is an advantage, for were the punches formed of hollow tubes with cutting edges, not only would the latter very quickly wear away, but the confetti would become packed in the tube and the operation would be necessarily slower. So it is preferred to stamp them. This, it is true, requires a stronger pressure, but that is easily obtained either with an hydraulic motor or a steam engine. At Paris some of the large manufacturers employ a 25 horse power engine.

The waste material varies from 25 to 30 per cent. It is far from being lost, for it is sent to the paper mill, where it is put into the paper stamp, which, under the dissolving action of water, triturates the pulp in drawing it out without altering the fibers, which are preserved more or less intact. This pulp will yield a paper of a little lower quality that may be easily utilized.

FIG. 2.—SERPENTINES AT A MASKED BALL.

The confetti obtained as above described are first beaten and worked in order to well scatter the small piles, and then mixed and stirred in order to confound the different colors. Finally, they are put up in bags or cornets, large or small, weighing 1½ ounce, 3 ounces or 2 pounds.

Thus packed, the confetti are ready for the battle, which, although innocent, would become more agreeable if a number of the combatants, in the streets at least, stopped picking up their ammunition from the dust.

It would be interesting to know the output of confetti at Paris on a public holiday. Being given that there now exist several manufacturers of this article, their sales would have to be added together, and this is a statistic that one will not fail to make ere long. But we can at present furnish an approximate figure. On Shrove Tuesday, Ferret & Co., on Etienne-Marcel Street, sold 66,000 pounds, say 600,000, of the smallest sized bags. Let us carry the calculation still further: the small cornet is very aristocratic and good for the redoubts of the Casino or the masked balls of the Opera House. The street vender sells it on the boulevards, carrying his stock in a basket (Fig. 1), but he also delivers the confetti by the "bushel," which is a modest glass. Now the small cornets hold about 3½ glasses, and it was therefore two million glasses of confetti that the Parisians threw into each other's faces last Shrove Tuesday, and, at the current price of two cents per glass, the merry fray cost about $40,000, 20 per cent. of which, at the most, went to the manufacturers, while the rest was divided among the middlemen.

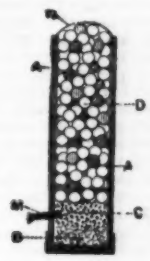


FIG. 4.—CONFETTI BOMB.

And yet, the confetti did not have all the honors of the day, favor having gone to the "serpentines." These are formed of a roll of paper which is thrown in the street or from balconies, and which winds around carriages and pedestrians in falling. At fancy dress balls they are thrown also at the dancers (Fig. 2).

The manufacture of these serpentines, which are exactly like the rolls of paper employed in telegraphy, is very simple. Let us suppose all the operations finished that are necessary to obtain colored paper sufficiently strong and adapted to the use that is to be made of it. This paper in most cases is wound in measure as it is manufactured. It suffices then to have upon the revolving wooden axis upon which the paper is superposed in rolls, circular disks forming knives and so spaced that, by the very fact of its winding, the sheet of paper is separated into a certain number of bands of the desired width (¼ inch). After a certain length has been obtained, the paper is cut parallel with the axis, the latter is removed, and we then have as many serpentines as there were disks, less one. It afterward suffices to glue the outer extremity of the paper (the unwinding having to begin from the center), and the serpentine is ready to deliver to the trade.

Up to the present, the mean length of these serpentines is 200 yards, and this explains why they can easily undulate from one side of a street to the other. Were they longer, they would not be practical, the resistance of the paper being inadequate; and such resistance alone limits their length, for paper mills manufacture rolls four feet in width by 30,000 feet in length for newspapers, and there would be nothing to prevent the manufacture of serpentines of as great a length were it possible to utilize them.

And now what new invention will be introduced to-morrow to entertain and amuse the great city? Manufacturers are about to bring out confetti rockets and confetti bombs, thus grouping in a single object the noise of the fire-cracker and the volley of paper missiles. Fig. 4 shows a bomb. It consists essentially of a strong cylinder formed of cardboard rolled three or four times upon itself. At B there is some asbestos, at C a small quantity of explosive material, and at D a mass of confetti. The whole is capped by paper, N, of little strength. The powder is ignited through the slow match, M, and it detonation expels the confetti, which ascend to a height of ten feet and fall in a true rain. The asbestos serves to prevent the transmission of fire to the cardboard.—*La Nature.*

THE POSITION OF PATHOLOGY AMONG THE BIOLOGICAL SCIENCES.*

By Professor RUDOLF VIRCHOW, Foreign Member of the Royal Society.

GENTLEMEN: It is now nearly ten years since this illustrious society conferred on me the unexpected honor of electing me one of its foreign members. Not alone this, but last autumn it deemed me worthy of a further honor, in awarding me the Copley medal—token of the highest recognition of my work, the significance of which far exceeds the distinctions which the changing favor of political powers is accustomed to bestow. Nevertheless, deeply as I appreciated this mark of its constant and increasing esteem, still I was not in a position to offer my thanks personally to the society. Numerous duties, official and private, the weight of which has increased with each year, compelled me to work continuously at home, and the extension of international relations, becoming more intimate, has for a long time restricted the freedom of my movements even during the vacations. With great indulgence, which I fully know how to appreciate, the council has allowed me to postpone the date of my appearance in its midst. Hence you see me only to-day among you, and I may tell you in person how very grateful I am to this society, and how great an incentive to new efforts your recognition has become to me.

Who of us is not in need of friendly encouragement in the changing events of life? True, happiness is not based on the appreciation of others, but on the con-

* Delivered before the Royal Society on Thursday, March 16, 1893.

sciousness of one's own honest labor. How otherwise should we hold our ground in the midst of the turmoil of the day? How should we preserve the hope of progress and of final victory against the attacks of opponents and the insults which are spared to no one who comes before the public? He who during a long and busy life is exposed to public opinion certainly learns to bear unjust criticism with equanimity, but this comes only through the confidence that our cause is the best, and that some day it must triumph. Such is our hope in our wrestlings for progress in science and art. Such is our hope in our struggles for civil and religious liberty, and in this hope we gradually become hardened against malicious attacks.

It is a kind of immunization which, I acknowledge, has also great drawbacks, for this hardening against unjust attacks leads very easily to a similar indifference toward just attacks, and, owing to the tendency to contradiction rooted in the nature of human thought, it finally leads also to indifference to praise and recognition. One withdraws again and again into oneself, discontented with the world and with oneself also; but who can so completely retire within himself that the consciousness of the insufficiency of human thought, and that the criticisms of opponents are justified, cannot break through the crust of even the most hardened self-consciousness? Happy is he who has courage enough to keep up or regain his connections with other men, and to take part in the common work. Thrice happy he who does not lack in this work the flattering commendation of esteemed colleagues.

Such were the thoughts which filled my mind as, looking forward to the present occasion, I reviewed my own life and the history of science, or to use another expression, the fortunes of our predecessors. How often have I found myself in a state of despondency, with a feeling of depression. And the history of science —what long periods of stagnation and numerous interruptions has it not experienced owing to the victory of erroneous doctrines. What has saved me is the habit of work, which has not forsaken me even in the days of outward misfortune—that habit of scientific work which has always appeared to me as a recreation, even after wearying and useless efforts in political, social and religious matters. That which has saved science is identically the same; it only appears to be different, because the co-operation of many is necessary to secure the advance of science; hence, the exalting and consoling thought that one nation after another comes to the front to take its share in the work.

When the star of science becomes dim in one nation it rises sooner or later to yet brighter glory in another, and thus one nation after another becomes the teacher of the world. No science more often than medicine has gone through these waxings and wanings of brilliancy; for medicine alone of all the sciences has, for more than 2,000 years, found ever-new homes in the course of a progress which, though often disturbed, has never been wholly arrested. It would lead us too far to illustrate this with examples drawn from the entire past. It is enough for my present purpose to take the outlines of modern medicine as the object of our consideration. Such a sketch, cursory as it must be, ought at the same time to throw some light on the intellectual relations of both nations, English and German, for these have taken a prominent part in establishing the principles of modern medicine.

The downfall of the old medicine, the so-called humoral pathology, was brought about in the beginning of the sixteenth century. We in Germany are inclined to attribute to our nation a decisive *role* in this memorable struggle. It was a man of our race, Andreas Vesalius, of Wesel, who transformed anatomy into an exact science, and who thus at one stroke created for medicine a solid foundation, which it has retained ever since, and, let us hope, will never again lose. But the principal blow to the old medicine was struck by his somewhat older contemporary, Paracelsus, that charlatan, yet gifted physician, who removed from among the beliefs of mankind the doctrine of the four *humores*, which, quasi-chemical in its construction, formed the basis of the old pathology. Strangely enough, he accomplished this with weapons borrowed from the armory of the Arabs, the successors of the Greeks and the chief representatives of the mediæval humoral pathology. From them also he borrowed alchemy and, at the same time, the fantastic spiritualism of the East, which found a clear expression in his doctrine of the "archæus," as the determining force in all living beings.

In this way the new medicine, at its very birth, absorbed the germs of that ruinous contradiction which, even up to this present century, has kept up the embittered strife of the schools. To Vesalius is due the exact tendency which arises from the observation of actual conditions, and which, without going further, we may call the anatomical. Paracelsus, who pronounced the anatomy of the dead body to be useless and sought for the basis of life as the highest goal of knowledge, demanded "contemplation" before all else; and, just as he himself arrived in this way at the metaphysical construction of the archæus, so he unchained among his followers a wild and absolutely fruitless mysticism. Nevertheless there lay hidden in that "contemplation" of his a healthy kernel which would not allow the intellectual activity which it had stirred up to come to rest.

It was the idea of *life* which formed the ultimate problem for all future research. Strangely enough, this idea, which always existed in the popular mind and which is in an unmistakable form present even among primitive nations, had been driven far into the background in scholastic medicine. Ever since the time of Hippocrates it had been the custom to use, instead of life, the obscure expression "φύσις," *natura*; but in vain does one seek for a more exact definition of the term. To Paracelsus, nature was living, and the basis of his life was that very "archæus," a force differing from matter, and separable from it, or, as he himself expressed it, in the sense of the Arabs, a spirit, "spiritus." In the compound organism man—the mikrokosmos—each part, according to him, had its own "archæus," but the whole was ruled by the "archæus maximus," the "spiritus rector." From this premiss has proceeded the long succession of vitalistic schools which, in ever-changing forms, and with ever-new nomenclature introduced into the notions of physicians this idea of a fundamental principal of life.

If the sagacious Georg Ernst Stahl, whose services to the development of chemistry are now acknowledged everywhere, substituted the soul for the "spiritus rector," and so created a system of animism, the last vestiges of which have disappeared from the school of Montpellier within our own time only, so also in turn did the pure vitalists build up on the dogma of specific dynamic energies maintained so stoutly by the physicists, that notion of the vital force the half spiritualistic and half physical character of which has contributed so much, even in our day, to puzzle and mislead men's minds. The doctrine of the vital force found its strongest support in the "Natur-philosophie," especially in that which, on German ground, soon obtained universal sovereignty. This summary exposition of mine has greatly anticipated the historical progress of the evolution of medicine.

It is now time to pay proper homage to the great investigator who made the more exact method the ruling one, and at the same time to award to this country, which brought him forth, its important share in determining the new direction of our science. Nearly 100 years had passed since Vesalius and Paracelsus had begun their work when William Harvey published his "Exercitatio anatomica de motu cordis et sanguinis in animalibus."

Here, for the first time, the anatomical examination of living parts was carried through, in an exemplary way according to experimental methods. All the objections that anatomy concerned itself with dead parts only were thus at once set aside; living action became the object of immediate observation, and this was done on one of the most important organs, one absolutely necessary to life, the varying activity of which constantly calls for the attention of the practical physician. Not only so, however, but a new mode of observation—the experimental method—was thus brought into use for research, a method through which a new branch of medical science, physiology, has been laboriously built up. The influence of this one wonderful discovery of Harvey on the ideas of men of his time and of his successors was memorable.

Among the men of his time the last support of Galenism disappeared with the proof of circulation; among his successors the comprehension of the causation of local processes dawned for the first time. Very ancient and highly difficult problems, such as inflammation, could now be attacked; a goodly piece of life also became intelligible, since one of the vital organs themselves could now be subjected to experiment, and to the astonishment of all, the action of this organ showed itself to be an absolutely *mechanical* one. The revulsion of thought was so complete that it has become since a difficulty hardly to be overcome to enter even in imagination into the ideas of the older physicians, to whom the circulation of the blood was unknown. Nevertheless, in spite of such striking results, the craving of man for more complete understanding remained unsatisfied. One saw the action of the living heart, but how did it live? What was this life the action of which one saw before one? In the heart itself the essence of life could not be recognized.

Harvey turned his attention to another object; he tried to observe the very beginnings of life in the incubated egg of the fowl and in the embryos of mammalian animals. He thereby soon arrived at the question of the significance of the egg in general, and enunciated the celebrated dictum, "Omne vivum ex ovo." Owing to the more extensive researches of modern investigators, this dictum, as is well known, proved too narrow for the whole animal kingdom, and is no longer exact when applied to plant life. Its validity for the higher animals, on the other hand, cannot be questioned, and it has formed one of the firm standpoints on which researches on sexuality and on the propagation of life have been based; but Harvey, on account of the deficiency of his optical instruments, was unable to see that which he was laboring to discover, namely, the process of organization as such, just as he had been unable in former times to see the continuity of the capillary flow. This imperfection lasted for a long time afterward, and thus it happened that even Albrecht Von Haller and John Hunter considered the formation of the area vasculosa in the incubated egg of the fowl as the commencement of organization, and, indeed, as the type of organization itself.

I will return to this point later; but for the present I should like first to draw your attention to a man whose importance for the further development of the doctrine of life has always appeared to me to have been uncommonly great and highly significant; but who, nevertheless, has sunk into unmerited oblivion, not only among posterity in general, but also, I think I may be allowed to say, even in the memory of his countrymen. I mean Francis Glisson, who was a contemporary of Harvey, and whose works appeared almost simultaneously with those of his more celebrated colleague; but the brilliancy of Harvey's discoveries was so great that the light which shone from Glisson's work table almost disappeared. I rejoice that on so auspicious an occasion I may recall the memory of the modest investigator and may offer him the tribute of gratitude which science has to award him.

When, thirty-five years ago, I published my little essay on Irritation and Irritability,* I did not know much more about Glisson than every student of medicine learns—namely, that there is in the liver a "capsula communis Glissonii," and, what was even less known, that this anatomist had written a small work on "Rachitis," which, indeed, was the first of its kind. In my own paper on this disease† I tried to demonstrate the circumspection and accuracy which are noticeable in this book, and which make it a typical model for all collective investigations; but even at that time I overlooked the fact that this was only the smallest merit of this wonderful man. It was only in the further course of my studies on the history of the doctrine of irritation and irritability that I made the discovery—an astonishing one to me—that the idea of irritability did not, as is generally thought, originate with Haller, but that the father of modern physiology and the Leyden school in which he had been brought up had borrowed this idea from Glisson.

I then stumbled on a series of almost forgotten publications of this original scholar, especially his "Tractatus de natura substantiæ energeticæ seu de vita naturæ ejusque tribus primis facultatibus, perceptiva, appetitiva et motiva," which appeared in London in 1672, and in which the ideas were further worked out, the outlines of which had already been brought forward in his "Anatomia hepatis," published in 1654. In this work (p. 400) the newly coined word "irritabilitas" appears, so far as I can find out, for the first time in literature. It may be noticed, by the way, that the expression "irritatio" is much older. I find it already in Celsus, but with an exclusively pathological signification. It appears also occasionally in later writers, and to this day it has not, speaking accurately, lost this original signification. It is otherwise with Glisson; to him irritability is a physiological property and irritation merely a process of life dependent on the natural faculties of living matter.

Thus he was led, through a process of "contemplation," to maintain the existence of the "biarchia," the "principium vitæ" or the "biusia," the "vita substantialis vel vitæ substantia." And in order to allow of no misunderstanding as to the source of his "contemplation," he adds distinctly that this is the "archæus" of Van Helmont—the "vis plastica" of plants and animals. In the further course of his philosophical discussions he nevertheless is led into the same by-path which has misled, even in the most recent times, so many learned men and even excellent observers. This is the by-path of *unlimited generalization*. The human mind is only too prone to render intelligible what is unintelligible in particular phenomena by generalizing them. Just as even in recent times an attempt has been made to render consciousness intelligible by representing it merely as a general property of matter, so Glisson thought he might attribute to the active principle ("principiumen ergeticum") which according to him is contained in all matter, the three faculties of living matter which he considered as fundamental—namely, the facultas perceptiva, appetitiva et motiva. All matter was sensitive, was thus stimulated to develop impulses, and moved itself as a consequence of these impulses.

It is not necessary for the purpose of our present inquiry to carry these quotations further, since they are quite, in the Paracelsian sense, contemplative in their nature; and especially as, in their generalization, they do not appear to be important for the history of advancing knowledge. That which is full of significance for us is concerned with actual life only, in the narrower sense of analytic science. It was not the "principium energeticum" set up by Glisson which stimulated his successors again to take up the thread of his observations, but rather this process of irritation described by him and the fundamental faculties of living matter on which it depended. In this way he has really led up to a more exact study of the actions of life and the properties of living matter. Unfortunately there intervened a mistaken conception, which led his followers again into a series of most serious errors. Glisson, following on this point also the example of Van Helmont, was convinced that nerves contracted when irritated.

He joined to this the idea that, through the contraction of the nerves, or even of the brain, the fluid contained in them was propelled toward the periphery. This notion, shared by Willis and many other physicians of that time, furnishes the reason why irritability was identified with contractility. Even the great master Hermann Boerhaave, and after him his pupil Gaubius, the first special writer on general pathology, considered sensation and motion as common properties of, at all events, all the solid parts of the body. The former thought it proved that hardly a single particle of the body existed which was not sensitive and did not move; and thus it becomes comprehensible how Haller himself carried this idea that irritability had the same significance as contractility from his school days in Leyden to his professorship in Gottingen. It was in this sense that he understood the irritability of the muscles, and in the same sense he denied this property to the nerves. This dispute about the irritability of muscles has continued far into the present century; its long duration becomes intelligible only when we bear in mind that, without the most exact knowledge of its historical development, even the very statement of the question is liable to be misunderstood.

As a matter of fact, so far as we know, the nerves are not contractile like the muscles; on the other hand, the muscles are not only contractile, but are also irritable. Irritability and contractility are not identical, even when they occur in the same part. The nerve current, on the other hand, cannot be compared with the blood stream; it does not consist in the movement of a fluid, but is of electrical nature, and hence there is no need for its production of a contraction of the nerve tubes. It was also an erroneous conclusion that every irritated part contracts. Instead of contraction, secretion, or, under certain circumstances, a more vigorous nutrition, may occur as the final result of irritation. Hence we use a more comprehensive term in order to express this final result, and call all forms of it "actions." While Glisson defined all "actio propria sic dicta" as "motus activus," we distinguish different kinds according to the nature of the effects, or, expressed otherwise, according to the direction of the activity (nutrition, formation and function); but we agree with the above thinker in the opinion that no vital energy is ever set free without stimulus; that therefore every action is of an irritative nature.* In this irritation, according to my idea, consists the "principium dividendi," according to which we must distinguish between active and passive processes of life, and in this way we gain also a basis for the fundamental division of pathological elementary processes. How much work has been necessary in order to render this conception possible. And how great, even now, is the number of our colleagues who have not fully accepted it. The reason for this difficulty is twofold. Most of the vital actions of life, whenever they manifest themselves by visible events, are of a compound nature. As a rule, very various, at times wholly unlike parts, each with its specific energy, combine to produce them. Not infrequently it thereby happens that in the visible sum of final effects one part behaves in an active, the other in a passive manner. It is only the most minute analysis of the phenomenon, tracing it right back to the elementary parts, which allows the total result to be resolved into its components; such an analysis cannot for the most part be expressed in current language except at great length. No language in the world is rich enough to

* Archiv fur Pathologische Anatomie und Physiologie, 1858, vol. xiv., p. 1.
† Ibid., 1853, vol. v., p. 410.

possess special expressions for each such combination. Only too often we help ourselves out of the difficulty by regarding the compound phenomenon as a simple one, and by expressing its character according to some chief trait which stands out in a commanding manner from the general picture. This is the practical difficulty. With it, however, a theoretical difficulty is very often combined. The human mind, owing to a natural impulse, seeks in the phenomena indications of their determining cause. The more complex the phenomenon, the more busy is the imagination in order to convert it into a simple one and to find a unitarian cause for it. So has it happened in respect to life, so in respect to disease. The course of thought followed by Glisson is opposeed to such an explanation. He had no scruple in dividing the unit of life into a large number of individual lives. Although the knowledge we now possess of the arrangements of the body was absolutely foreign to him, yet he arrived quite logically at the vita propria, the proper elementary life, of the several parts. To be sure, this expression, as far I can see, is not to be found in his works, but occurs first in those of Gaubius; but Glisson says distinctly:* "Quod vivit per se, vivit vitam a nulla creatura præter se ipsum dependentem. Hoc enim verba vivere per se sonant." The unitarian efforts of the following period relentlessly passed over the tendency of which I have just spoken. Some returned to the old Mosaic dictum, "the life of the body is in the blood;" others gave the nervous system, and the brain especially, the first place in their consideration. Thus once more was renewed the old struggle which for thousands of years had divided the schools of medicine into humoral and solidar pathology. Even when we ourselves entered on scientific work, hæmato-pathologists stood in hostile attitude to neuro-pathologists.

In England humoral pathology found a strong support in the great and legitimate authority of John Hunter. Although this distinguished practitioner never shared the one-sidedness of the later pathologists, but rather attributed to the solid parts the living principle—the existence of which he assumed—nevertheless, in his investigations, the blood took precedence over all other parts as the chief vehicle of life.

One must, however, recall to mind that Hunter laid special stress on the fact that life and organization are not bound to each other, since animal substances which are not organized can possess life. He started, as has already been noticed, from the erroneous conception that eggs are *not* organized, and that it was not till after incubation that the first act of organization—namely, the formation of vessels—took place. He considered his "diffuse matter" ("materia vitæ diffusa") as the actual carrier of life; and this was to be met with not only in the solid parts, but in the blood also. This matter, according to him, existed in the brain in a remarkable degree of concentration, but its presence was quite independent of all nervous structures, as is shown by the example of the lower animals which possess no nerves. In the posthumous writings of Hunter, which Owen has collected, the very striking expression "simple life" is met with, a state most clearly to be recognized in plants and the lowest animals.

This simple life was in Hunter's view the ultimate source of all living actions, pathological as well as physiological. Hunter was out and out a vitalist, but his materialistic vitalism, so to speak, differed *toto cælo* from the dynamic vitalism of the German schools. If living matter existed independently of all organization, such living matter was beyond the scope of anatomical investigation; but, on the other hand, if it were present in non-organized parts, such as an egg, it was in itself the ultimate source of the organization which subsequently makes its appearance in these parts. It must, therefore, to adopt a later mode of expression, be of a plastic nature. Here Hunter's notion agreed with that of the plastic lymph, as developed by Hewson; and it was only logical that Schultzenstein applied it to the blood at last, and designated as "plasma" the material of life present in the blood. In this way the formative and nutritive matter necessary to physiological life, as well as the plastic exudations occurring in diseased conditions, could be attributed to the same material—a highly satisfactory result in appearance, and one providing a most convenient basis for interpretations. The exponents of this notion had no scruples in going one step further and in providing this material of life with a technical name. They called it "fibrin." Evidently this did not quite correspond with Hunter's ideas, for we know of no such matter, either in the egg or in the plants or in the lower animals, as that to which he attributed simple life; but the necessities of pathology overcame all such scruples and the plastic exudations were received as undoubted evidence that fibrin possessed the power of becoming organized. They formed, in the crasis doctrine of the Vienna school, the bright spot of this newest kind of hæmato-pathology. Whenever fibrin failed, blastemata were brought to the fore. Ever since Schwann had given the name of cytoblastema to the organizing material of the egg, the way had been open for assuming, in other places, the existence of material with this ambiguous name. But of course through these steps the one simple matter of life predicated by Hunter was replaced by many "matters of life," and thus the entire advantage gained by the exposition of a unitary theory of life was at once lost. Even when, finally, protoplasm was recognized as cell contents, and thus the one requisite of Hunter—namely, that the material of life must also be contained in the individual parts—appeared to be fulfilled, yet no single specific material was thereby arrived at. No one dreamed of regarding protoplasm as fibrin, and least of all did any one consider it a simple chemical body.

By the conception of the blastema, however, there had been reawakened a thought which had occupied the minds of men from the earliest times. If a plastic matter capable of being organized really existed in the body, then the organization of the same must present the first reliable example of epigenesis. The problem of the "generatio æquivoca," which had been fought over for so long a time, now appeared to be solved. What Harvey had taught concerning the descent from the egg was rejected concerning the continuous descent from exudation. Several generations of young medical men have been educated in this belief. I myself remember my "epigenetic" youth with no little regret, and I have had hard work to force my way through to the recognition of the sober truth. Meanwhile, the attention of other bodies of inquirers had been directed to the tissues of the body. Among these, in view of their importance, the nervous tissues, and especially the mass of nervous tissues in the brain and spinal cord, rank highest. Hunter also had acknowledged the importance of the brain, and hence called it the "materia vitæ coacervata." It was easily seen that it contained no fibrin, but experimental research showed also that neither the brain nor the spinal cord was of the same nature throughout all its parts. The more accurate the experiments the smaller became the region which, in the strictest sense, is the vital part, until Flourens limited it to one single spot, the knot of life ("nœud vital").

Was the unity of life found in this way? By no means. The brain is no more and no less vital than the heart; for life is present in the egg long before the brain and heart are formed, and all plants, together with an immense number of animals, possess neither the one nor the other. In the highly compound organization of man the brain and spinal cord have a certain determining action on other parts necessary to life. Their disturbance may immediately be followed by the disturbance of other vital organs, and sudden death may ensue. But the collective death of a compound animal no more implies the local death of all its special parts than the local death of some of the latter is incompatible with the collective life of the animal. As has been well said, at the death of a compound organism there is a "primum moriens," a part which first ceases to live; then follow, at long intervals sometimes, the other organs, one after the other, up to the "ultimum moriens." Hours and days may pass between the total death of the individual and the local death of the parts. The fewer nerves a part contains, the more slowly usually does it die; I therefore consider the process of dying in the compound organism as the best illustration of the individual life of the several constituent parts, which is in its turn the first axiom necessary for the study and for the understanding of life. A long time, however, elapsed before it was possible to return to this starting point and to obtain a considerable number of supporters for the doctrine of the "vita propria." The attention of many observers was drawn to a totally different side of the question.

In the last decade of the past century, about the same time that John Hunter, starting from careful anatomical investigations and exact observations of surgical practice, worked out his idea of the material of life, a new system of medicine was founded in Scotland, the so-called Brownian system, which was based on quite different premises. Brown also was a vitalist; he, too, constructed not merely a pathological and therapeutic system of vitalism, but a physiological one, though his doctrine was dynamic in its character. There is but little to be noticed therein of the material anatomical foundation of exact medicine. It is concerned principally with contemplations of the forces of the living organism. One can understand to some extent how this happened if one keeps in view the history of the development of this extraordinary personality. I cannot go into this here, but anyhow the remarkable fact remains that the two contemporaries, Brown and Hunter, worked near each other without its appearing from their writings that they were acquainted with one another. Brown struck out his own line and stuck to it, without troubling himself about the rest of the medical world. And yet even his first work, "Elementa Medicinæ," had the effect of an earthquake; the whole European continent was shaken by it, and even the physicians of the recently opened new world bent under the yoke of revolutionary ideas; and in a few years the aspect of the whole field of medicine was entirely changed. True, the triumph was but short; the Brownian system disappeared as it had come, a meteor in the starry heaven of science. There would be no reason to go into it more fully had not the impulse which he had given instigated other men, and been permanently applied by them to the true service of science. This impulse was founded on the fact that irritability, or, as Brown called it, "incitability," was thus reinstated as the starting point of the theory; but, along with this, the stimuli which set living substances in action, the "potestates incitantes," were brought to the fore. In so far that stimuli produce a state of irritation ("incitatio"), or, as Brown called it later, excitement, they came to be viewed not only as the cause of health and disease, but even of life itself; for excitement, so he said, is the true cause of life. But, as excitement stands in a certain relation to the strength of the stimulus, a state of good health was only possible with a normal degree of stimulus, while an excess or a lack of stimulus brought diseased conditions in its wake. Of course excitement is dependent also on irritability, with a certain quantity of which, in the form of energy, every living being is endowed at the beginning of its life.

The division of diseases, according to the amount of vital force visible in them, into sthenic and asthenic has never been abandoned since, though acknowledged perhaps in a less precise manner; it has sometimes been brought more prominently forward and sometimes been thrown into the background. In Germany, Schonlein was the one of all others who took this doctrine as the foundation of his opinion on special cases of disease and for his guide in treatment. But the application of the Brownian principles to physiology has been of far greater importance. If life itself were dependent on external stimuli, the notion of the spontaneity of vital actions, a notion still in force, must lose all significance. Certain stimuli would in that case prove to be necessary conditions of vital activity, without which life could at best be carried on in a latent form only. Certainly, even for this latent life, the question remained open, How does it come to pass and in what does it practically consist? Brown avoided this ticklish question, not without great skill, by drawing the whole attention to active life and to the stimuli which call forth action. To speak openly, science has since then deflected little, or not at all, from this guiding notion.

Even now we cannot say what latent life is. We simply know that through external stimuli it may be converted into active life, and hence irritability is considered by us as the surest sign of life, not, of course, of the general life of all matter in the sense of Glisson, but of the real and individual life of special living organisms. Brown remarked with reason, that through irritability the living substance is differentiated from the same substance in its dead condition or from any other lifeless matter. Nevertheless, neither irritability nor incitability, neither irritation nor incitation, explains the essence of the living substance, and therefore neither explains the essence of life. In Germany the physiologists especially took up this question. Among the first was Alexander Von Humboldt, who in his various writings, especially in his celebrated treatise on the irritated muscle and nerve fiber, entered into the question. In the end he held fast to the assumption of a vital force. The majority of pathologists and physicians followed in his footsteps and long and fierce controversies were necessary before, nearly half a century later, the belief in a vital force was destroyed. When Dubois Reymond had demonstrated the electrical current in muscle and nerve in all its characters and, at the end of his work, had also disclosed the inadmissibility of vital force, then the venerable Humboldt formally and expressly renounced the dream of his youth, with the masterly submission of the true naturalist to the recognized natural law. The hypothesis of a vital force of life had, however, in regard to Brown's theory neither a positive nor a negative value. Johannes Muller rescued for general physiology, in which it has ever since kept its place, that which was valuable in Brown's system, the doctrine of the integrating life stimuli. The occasional stimuli which produce disease have found their place in etiology; their significance has become more and more sharply defined the more accurately we have learned to distinguish between the causes and the essences of disease—a distinction which became more difficult as the "causæ vivæ" of diseases became known in ever-increasing numbers. And now a new task has arisen—namely, to draw into our sphere of observation the life of the causative agents themselves.

The way in which pathology has tried to approach the desired goal, to fathom the living substance in its diseased conditions, has led us a great step forward. Pathological anatomy especially has opened this road. The more numerous its observations and the more it penetrated into the details of the lesions, the smaller became the field of so-called general diseases. The first steps of mediæval anatomists had the effect of drawing the attention to local diseases. In the first and longest period, which one may define as that of regionism, the pathological anatomists sought the cause of disease in one of the larger regions or cavities of the body—in the head, chest or abdomen. In the second period, ushered in by the immortal work of Morgagni, shortly before the time of which I last spoke—the time of Brown and Hunter—they endeavored to find in a certain region the actual organ which might be considered as the seat of disease. On this foundation arose the Parisian school of organicism, which, until late in this century, held a dominant position in pathology. In this school already they recognized that not the organ, nor even a portion of it, could be the ultimate object of research. Xavier Bichat divided the organs into tissues, and showed that in the same organ sometimes one and sometimes another tissue might be the seat of disease. From that time forward the eye of the pathological anatomist was directed chiefly to the changes in the tissues, but it soon became apparent that even the tissues are not simple substances. Since the third decade of this century the microscope has disclosed the existence of cells, first in plants and very soon afterward in animals. Only living beings contain cells, and vegetable and animal cells show so much similarity of structure that one can demonstrate in them the actual product of organization. This conviction has become general, since through our embryologists, especially through Schwann, proof has been afforded that the construction of embryonic tissues was derived from cells also in the highest animals and in man himself. In the fourth decade of this century the science of pathological anatomy had already begun to be directed toward cells. These researches very soon struck on great difficulties. Many tissues, even in their developed state, appeared to contain neither cells nor their equivalents; nevertheless, I have been able to demonstrate their existence in those tissues in which their presence appeared to be most doubtful—viz., in bone and connective tissues.

At the present time we are so far advanced as to be able to say that every living tissue contains cellular elements. We go a step further even, for we require that no tissue alone should be called living in which the constant occurrence of cells cannot be shown. A still greater difficulty then appeared—namely, to discover in what way new cells originated. The answer to this question had been very heavily prejudiced by the so-called cell theory of Schwann. Inasmuch as this very trustworthy investigator asserted that new cells originated from unformed matter, from "cytoblastema," there was opened up a wide road to the old doctrine of the "generatio æquivoca," which afforded all partisans of plastic materials an easy way of reviving their dogma. The discovery of cells of connective and allied tissues gave me the first possibility of finding a cellular matrix for many new growths. One observation followed another, and I was soon in a position to give utterance to the dictum, "Omnis cellula a cellula." And so the great gap was closed which Harvey's ovistic theory had left in the history of new growth, or, to speak more generally, in the history of animal organization. The begetting of a new cell from a previous cell supplements the reproduction of one individual from another, of the child from the mother. The law of the continuity of animal development is therefore identical with the law of heredity, and this I now was able to apply to the whole field of pathological new formation. I blocked forever the last loophole of the opponents, the doctrine of the specific cells of pathology, by showing that even diseased life produced no cells for which types and ancestors were not forthcoming in normal life.

These are the fundamental principles of cellular pathology. In proportion as they have become more certain, and lastly of more general value, they have

* Glisson, "Anatomia hepatis," "Ad lectorem," N. 17.

also secured for themselves great importance in physiology. The cell is not only the seat and vehicle of disease, but also the seat and carrier of individual life; in it resides the "vita propria." It possesses the property of irritability, and the changes in its substance, provided these do not destroy life, produce local disease. Disease presupposes life; should the cell die, its disease also comes to an end. Certainly, as a consequence, the neighboring and even far distant cells may become diseased, but as regards the cell itself the susceptibility to disease is extinguished with life.

Since the cellular constitution of plants and animals has been proved, and since cells have become recognized as the essentially living elements, the new science of biology has sprung up. It has not brought us the solution of the ultimate riddle of life, but it has provided concrete, material, anatomical objects for investigation, the properties, the actions, and the passions of which we can analyze. It has put an end to the wild confusion of fantastic and arbitrary notions such as I have just mentioned; it has placed in a strong light the immeasurable importance of anatomy, even in the most delicate conditions of the body; and lastly it has made us aware of the close similarity of life in the highest and lowest organisms, and has thus afforded us invaluable means for comparative investigation. Pathology has also its place, and one certainly not without honor, in this science of biology; for to pathology we are indebted for the knowledge that the opposition between healthy and diseased life is not to be sought in a fundamental difference of the two lives, not in an alteration of the essence, but only in an alteration of the conditions. Pathology has been released from the anomalous and isolated position which it had occupied for thousands of years. By applying its revelations not only to the diseases of man, but also to those of animals, even the smallest and lowest, and to those of plants, it in the best manner helps to strengthen biological knowledg and to narrow still more that region of the unknown which still surrounds the intimate structure of living matter. It is no longer merely applied physiology; it has become physiology itself. Nothing has more contributed thereto than the constant scientific union which has endured for more than 300 years between English and German investigators and to which we to-day add yet another link. May this union never be broken.—*The Lancet.*

FERTILIZATION AND HYBRIDIZATION.

IN the *Memoirs* of the *Societe des Sciences Physiques et Naturelles de Bordeaux* (1891, p. 301), A. Millardet gives pratical instructions for the hybridization of the vine and the culture of the hybrids. None of the so-called hybrid vines cultivated in Europe are, he states, true hybrids, *i. e.*, products of the crossing of distinct species; they all spring from the crossing of different races of the same species, *Vitis vinifera*. In the native state all species of *Vitis* have two kinds of flower, male and hermaphrodite, the pistil being subject to all degrees of abortion in the former. There is a remarkable difference in the stamens of the two kinds of flower; in the hermaphrodite the filaments are short and curved backward, so as to remove the anther as far as possible from the stigma; in the male flowers they are longer and erect. But in the cultivated varieties, all of which have only hermaphrodite flowers, the filaments are long and erect, as in the male flowers of the wild plant. There is also a difference in the pollen grains; those from the short curved stamens will not germinate in a solution of sugar, but they will, under certain circumstances, germinate on the stigma. In the wild state the vine is anemophilous, though the flowers have a powerful odor, the purpose of which is obscure. In the cultivated state, two small Coleoptera were observed abundantly on the flowers, and they may also probably take some part in the pollination. The author states that, in the vine, it is the male parent that exercises the preponderating influence on the hybrid.

In the *Botanical Gazette* (1892, p. 282), Mr. S. A. Beach enumerates eight American species of vine and their hybrids and crosses in which he has observed self-pollination.

In the same journal (1892, p. 281), Professor C. V. Riley enumerates fourteen insects as taking part in the caprification of the wild figs of North America. He recommends the importation for this purpose of *Blastophaga psenes* to the fig growers of California.

A. Schulz publishes the result of a series of observations on the flowers of trees usually regarded as unisexual. In *Alnus glutinosa* hermaphrodite flowers, or transitional forms between these and unisexual, are usually to be found at the base of the male catkins. Hermaphrodite flowers also occur in the birch, though less frequently; very rarely in the hazel; in the oak there are frequently ovaries at the base of the male catkins, and rudiments of stamens in the female flowers. In the ash all kinds of condition may be met with, male, female, and hermaphrodite flowers, and monoecious, dioecious, and polygamous individuals. The ash is probably on the road to becoming completely dioecious (*Ber. Deutsch. Bot. Gesell.*, 1892, pp. 303 and 395).

Herr W. Rimpau has carried out a series of experiments on the crossing of some of our most common agricultural plants. If a new form exhibits great variability in its descendants, it is probably a hybrid; if, on the contrary, the descendants maintain great constancy, it is most likely a spontaneous variety. The author describes ten artificial and nine natural hybrids of wheat, and also obtained a fertile hybrid between wheat and rye. Of barley two artificial and six natural hybrids are enumerated; in no case did he succeed in fertilizing a two-rowed barley by the pollen of a variety with a larger number of rows. Of oats, five natural but no artificial hybrids were obtained. Peas produce very natural hybrids; with the beet crossing is much more common (*Kreuzungsproducte landwirthschaftlicher Cultur-pflanzen*, Berlin, 1891).

Professor C. V. Riley recapitulates the very interesting facts connected with the fertilization of *Yucca*, which he has had under observation for about twenty years. He states that all the species of *Yucca* belong to the class of plants that can be pollinated by a single species of insect only. The mode of pollination of *Yucca filamentosa* by the female of *Pronuba Yuccasella* is described in detail. In all the species of *Yucca* self-pollination is almost impossible. The object of the visit of the *Pronuba* is the deposition of its eggs in the ovules of the *Yucca*, the coats of which it pierces with its ovipositor. This is always effected as soon as the flower opens; and, the moment an egg has been deposited, the insect rushes to the anthers and carries a quantity of pollen to the stigma, stuffing it into the stigmatic cavity with its proboscis. This may take place ten or twelve times in the same flower, that number of ovules being destroyed; but as the number of ovules in the pistil is very large, this does not sensibly effect the fertility of the pistil. That *Yucca filamentosa* is dependent on the visits of *Pronuba Yuccasella* is shown by the fact that in Washington and St. Louis, where it flowers a fortnight before the arrival of the moth, it does not set its fruit, while in Philadelphia, where it flowers a fortnight later, it produces abundance of fruit ("Third Annual Report of Missouri Botanical Garden," 1892).

A series of experiments, carried out by Miss M. Reed (*Bot. Gazette*, 1892, p. 330), mostly on *Petunias*, fully confirm Darwin's statement that cross-fertilized produce more seed vessels than self-fertilized plants, and that the capsules are heavier.

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